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PREFACE

These Proceedings contain most of the papers presented at the work groups and general session of the 46th meeting of the Southern Pasture and Forage Crop Improvement Conference (SPFCIC) held at Kilgore, Texas. These reports are current developments in forage crop and animal science research and extension, and it is fortunate that they are documented herein. Their value will be determined by their usefulness to future scientists.

Formal meetings are just a part of SPFCIC. Unfortunately, it is difficult to document or measure the benefit of the discussions and observations of participants before and after the work groups, general session or during field trips to visit livestock operations in East Texas or discuss research at the Overton Research Center.

The combination of the field and meeting room made an ideal forum, but it was the interest and dedication that the participants had for their work that made the 46th SPFCIC a successful meeting. It was the hard work and planning on the part of our Texas hosts, program and work group chairmen that made the meeting possible.

Rob Kalmbacher
Chairman, 46th SPFCIC

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SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE, A HISTORY

Glenn W. Burton

On this, the 50th birthday of this conference, it seems fitting to record for posterity a brief history of the SPFCIC. To assist me are the minutes of 45 meetings supplied by staff members of the U.S. Department of Agriculture. A set of these kept by Homer Wells and John Miller for many years are filed at the Georgia Coastal Plain Experiment Station Library. Also, I have letters from four of the 41 people from 13 states who registered for the first Conference held at Tifton, GA, July 23 and 24, 1940.

In the minutes is a three-page letter from Dr. O. S. Aamodt, Principal Agronomist, USDA Forage Crop Division, describing similar recently organized groups that concludes as follows: "It would seem desirable and proper at some time in the near future to bring together the pasture and forage workers in the Southern States for a two-day conference at some point such as Tifton, Georgia, where a great deal of excellent grass and legume improvement and pasture work is under way. I have suggested Tifton as a possible meeting point for such a group since it is centrally located and the results obtained there should be applicable to a large part of the Coastal Plain. I wish to give you my assurance that in the event such a conference is organized that we, in the Division of Forage Crops will cooperate in every possible way in the development of a coordinated grassland research program for the South."

At a preliminary meeting on Feb. 7 and 8, 1940, organizational plans for the SPFCIC were developed and an executive committee that included E. N. Fergus, R. E. Blaser, G. W. Burton, and R. L. Lovvorn, Chairman was elected. The group accepted an invitation from Silas Starr, Director of the Georgia Coastal Plain Experiment Station to hold the first meeting of the SPFCIC at Tifton, Ga. The program for the first Conference read as follows:

<u>July 23 - Tuesday morning</u>

9:00 a.m. Inspection of pasture and forage crop plots - led by J. L. Stephens

<u>July 23 - Tuesday afternoon</u>

2:00 p.m. Round-table discussion (no papers--everyone participating) of fertility, seeding, grazing and management problems. R. L. Lovvorn, Chairman

<u>July 24 - Wednesday morning</u>

9:00 a.m. Inspection of breeding plots - led by G. W. Burton

<u>July 24 - Wednesday afternoon</u>

2:00 p.m. Round-table discussion (no papers--everyone participating) of breeding and improvement problems. Glenn W. Burton, Chairman

Commenting on our first meeting, Roy Blaser in his letter said, "We listened to research leaders at the Coastal Plain Experiment Station while they explained and discussed various objectives with breeding, fertilization, cutting and grazing management of field plot and grazing research. After several hours of field inspection, we had rather detailed and open discussions on improving techniques and we set objectives to improve our research. The discussions were open and frank, 'there were no sacred cows'. All results of research were openly discussed and ideas were readily shared to advance forage and pasture research in the southern region."

Research Geneticist, USDA-ARS, Coastal Plain Experiment Station, Tifton, GA 31793

Roy Lovvorn added, "As you will remember, there was no agenda, only very informal discussions in which practically everyone participated. The fortunate aspect is that a seed was planted that has grown to maturity 50 years later."

Howard Hyland, who for many years was the USDA person to whom we turned for grass and legume introductions wrote, "the first meeting at Tifton was most informative for me because it gave me a chance to meet researchers I had known only by name."

Across the years as the SPFCIC has met in every southern state, one or more times, the program has become more formal. There have been more titled papers, symposia, and invited speakers. As scientists have become more specialized, work groups for breeders, ecologists, physiologists, utilizers, etc. have been developed. Discussions have been reduced except for one on one or small groups volunteer sessions that help the "generalists" get the information they need. The opportunity to see and examine research underway at the stations visited continues to be a highlight of every conference. Tours that reveal research findings in use on the farm or ranch always interest those who attend.

This "1990 SPFCIC in Texas" at Overton with a review of the Overton research, four symposia-like workshops, a general session, several tours and five food functions is the biggest ever. Surely it will be one to remember.

In my letters to the survivors of the first conference, I asked for their appraisal of the value of the SPFCIC to them individually, to their profession and to the improvement of forage and pastures in the South. Excerpts from their response to my request follow:

Otto Sell said, "The SPFCIC brought the specialists from different disciplines and different environments, together, so that we all became better informed, and individually were called on to contribute of our specialties. The SPFCIC thus contributed greatly to the development of a balanced agriculture including livestock of our individual states and of the entire South. To those of us who in the '30's came from a balanced agriculture and green landscape, it was quite a shock and depressing to see the prevailing bare, eroding fields and the prevailing poverty in the South. It has been gratifying to see the changes in our agriculture and landscape in the South, due at least in part to our grassland researchers and the part the SPFCIC played in this."

Roy Blaser wrote, "The first meeting helped to improve the quality and quantity of research and to obtain more research per dollar by laying a foundation for cooperative research. This meeting helped to knock down the "self-centered ivory towers'. The meeting set a precedence for inter- and intra-disciplinary research. The inputs from Washington and field personnel of the Division of Forage Crops and Diseases were impressive. Senior and junior scientists were brought together in small groups to discuss special research problems during meals and intermissions. This was especially helpful to me, a junior scientist. It is my opinion that this SPFCIC meeting helped with establishing the concept of regional research."

Howard Hyland said, "those Forage Grass and Pastures Conferences provided an excellent media to promote the success of the work done at Tifton and elsewhere."

Roy Lovvorn supplied the value of the SPFCIC to an Experiment Station Director and CSRS Administrator when he wrote: "I became Director of the Agricultural Experiment Station, North Carolina State University in 1955 and during my 14 years in this position I served almost continuously as the advisor to SPFCIC as well as the administrative advisor to the S-12 regional forage crops committee. I know that the Southern Experiment State Directors have a high regard for the organization because they have seen how cooperation between scientists has been achieved, thus getting more research for the dollar - a situation they relate to.

In 1969, I was named Administrator of the Cooperative State Research Service, U.S. Department of Agriculture. I'm sure my peers had much to do with my selection. Nevertheless, in that position I had the responsibility, among other duties, of justifying before the appropriation committees of the congress the funds for agricultural research at the state experiment stations. A universal question that was always asked by members of the congress was 'How do you prevent duplication of efforts between the states?' As a matter of fact, you don't, but the record of SPFCIC is a wonderful example of the value of cooperation between scientists."

Bill Woodhouse had just returned home after eight weeks in the hospital, was improving but didn't feel like writing. At the Conference, I learned that Bill had died.

What can I, the sixth and final survivor of the 41 who registered for the first SPFCIC, add other than a loud "Amen". They may not have "said it all" but they made an excellent case for continuing the SPFCIC for another 50 years. Those of us in pasture and forage research in the South have made progress but there are many tough problems yet to be solved. Their solution will demand the cooperation between all of us, particularly animal and plant scientists, that SPFCIC fosters. We must never forget that finally we are working for the cow and her keeper. The degree to which our efforts satisfy their needs will measure our success.

PASTURE AND FORAGE CROP PROGRESS IN THE LAST 54 YEARS

Glenn W. Burton

To measure progress, we need to know where we started.

In South Georgia in 1936, cultivated fields were fenced and cattle had access to everything else. The situation was called "free range". Most of the timber had been cut and sold by the owner to save his farm. This released the native, largely bunch grasses, but they were so low in quality and yield that it took at least 20 acres to keep a cow alive. Her nutrition was so poor that after having a calf, she required two years to recover and have another one. Most of the cattle received no winter feed and a few starved to death. The man who owned the cattle didn't own the land. For him it was "free range". Knowing that fire would improve the forage and suppress regeneration of the forest, the cattle owners helped lightning burn the woods. Even so, later research showed that the burned range could only produce about 12 pounds of liveweight gain per acre per year. Steers grew so slowly on the native range that several years were required for them to get large enough to slaughter. A New York buyer reportedly wired a Georgia buyer to send him 200, 800-pound steers. The Georgia buyer wired back, "To fill your order, we are having to ship you 800, 200-pound steers." We bought all our beef from a small market where the butcher slaughtered whatever he could buy. More times than not when I'd go in to buy beef, Mr. Fletcher would say, "We've got some but we'll have to put it through the grinder first." In those days, hamburger was never too fat.

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Cotton was king - the principal crop grown. Corn to feed the mules and the family planted on 4-foot centers and fertilized with a "sack of soda" (16 lbs. of N per acre) if any was left after fertilizing the cotton averaged less than 10 bushels per acre.

Fence laws that required livestock to be fenced terminated free range and created a need for improved pastures. On the more fertile black belt and delta soils, dallisgrass, Paspalum dilatatum was planted. On the infertile sandy soils, neither it nor any of the other promising forage grasses from Africa and South America would grow without some added fertilizer.

Among the grasses that we started to work with were bermudagrass, Cynodon dactylon; pangolagrass, Digitaria decumbens; sudangrass, Sorghum sudangrass; pearl millet, Pennisetum glaucum; bahiagrass, Paspalum notatum and dallisgrass, Paspalum dilatatum. Because no one had ever tried to breed them before, we had to count chromosome numbers, learn how to make crosses, study their breeding behavior, and develop new breeding methods for each of them. I shall long remember my first description of my work to a group of farmers. When I mentioned bermudagrass they said, "Not bermudagrass. It's our worst weed." They were right. In cultivated crops, the man with a mule and a plow was no match for bermudagrass once it became well established. After that, I talked about the other grasses and said as little about bermudagrass as possible for several years.

In June of 1942, my USDA boss, looking at my work, noticed that the very vigorous hybrid destined to be named "Coastal bermuda" was producing no seed heads. "Common bermuda" beside it had a mass of seed heads. "Will it produce seed?" he asked. When I said "no", he asked, "How do you expect to plant it?" When I answered "vegetatively," he said, "Whoever heard of planting pastures vegetatively. If it were mine, I'd throw it away." When I asked, "Do I have to?", he answered "No." It took a lot of work

to develop planting and distribution methods and to overcome the prejudice farmers had for bermudagrass. But Coastal bermudagrass yielding nearly twice as much as common and released in 1943 has now been planted on some 10,000,000 acres in the USA.

In the December, 1942 Southern Seedsman magazine, county agent E. H. Finlayson described a new bahiagrass growing wild around the remains of the old Perdido wharf near Pensacola, Florida. We found it to be Paspalum notatum var saure, a sexual diploid, a good seeder and a highly productive, well-adapted perennial grass. We were able to show later that it most certainly came to Florida in the digestive tract of cattle shipped from Berduc Island in the Parana River in northern Argentina and unloaded at the old Perdido wharf before it was destroyed by a hurricane. Named Pensacola bahiagrass, it has become the most widely grown seed propagated pasture grass in the deep South.

All of the bahiagrass introductions we have received from the millions of hectares growing in Brazil, Argentina, Uruguay, and Paraguay have been obligate apomictics. The species could only be improved by testing, selecting and naming the best of them. Argentine bahiagrass is an example. Only after creating a sexual tetraploid by doubling the chromosomes in the sexual diploid Pensacola variety, could we break apomixis and start genetic improvement of tetraploid bahiagrass. Tifton 54 is the first product of that effort.

Pangolagrass, PI 111110 from South Africa, a sterile crabgrass easily propagated vegetatively, lacked winterhardiness at Tifton but became an important perennial pasture grass in south Florida and the Caribbean region. Transvala, Taiwan, Survenola, and Slenderstem are more recently released Digitaria spp. cultivars.

On the heavier soils and in Texas and Oklahoma, sudangrass varieties such as Greenleaf, Piper, Texas Sweet, Tift and Wheeler supplied good temporary warm-season grazing. Sorghum sudangrass hybrids such as Suhi appeared in the 1960's and yielding more replaced the sudangrass cultivars.

On the sandy soils, pearl millet commonly called cattail millet, was the best summer annual pasture grass. Starr, a synthetic, leafier and more productive than Cattail was released in 1951. Gahi-1 pearl millet, a unique mixture of six chance hybrids released in 1958 was leafier, later maturing and yielded 50% more than cattail. Its seed was produced by harvesting all seed from a field planted to a mixture of equal numbers of pure live seeds of four selected inbred lines 13, 18, 23, and 26 that flowered at the same time and produced good hybrids in all combinations. With our discovery and development of cytoplasmic male sterility in pearl millet, we were able to replace Gahi 1 with F_1 singlecrosses tall Gahi 3 and short Tifleaf 1 producing less dry matter but more "cow matter" (meat and milk) than Gahi 3. Tifleaf 2, released in 1987 is a rust and leafspot resistant version of Tifleaf 1.

To extend the northern limit of bermudagrass, Midland, an F_1 hybrid between Coastal and an Indiana common, was produced and released in 1953. Tifton 44, an F_1 hybrid between Coastal and a common from Berlin, Germany, as winterhardy but more disease resistant and productive than Midland, was released in 1978. Hardy, developed in Oklahoma is the most winterhardy improved bermudagrass.

To improve the quality of bermudagrass so cattle consuming it would make better daily gains, we needed a screening method that could be applied to a few grams of forage. We first tried armyworms and found their 5-day weight gains correlated well with average daily gains (ADG) cattle made on several different grasses. We then found that 10 g of uniformly ground dry forage placed in a nylon bag and left in the rumen of a fistulated steer for 72 hours would lose the same percent of dry matter that was digested in a standard digestion trial with steers. With this screen, we selected

from F_1s between Coastal and Kenya PI 255445, Coastcross-1 that yielded no more dry matter than Coastal but was 12% more digestible and gave 40% better ADGs and liveweight gains (LWG) per acre when grazed. The more efficient Tilley and Terry *in vitro* dry matter digestibility IVDMD method has replaced the nylon bag procedure and is currently being used to measure the digestibility of the forage cut from every plot in our yield trials. The near infrared reflectance spectrascopy (NIRS) method, calibrated with IVDMD, is supplementing or replacing IVDMD in a number of forage quality laboratories.

Callie bermudagrass, a chance hybrid found in an abandoned grass introduction garden in the early 1970's, gave outstanding yields but was very susceptible to rust and winterkilling. Crossed with Coastal, it produced a number of F_1 hybrids, the best of which became Tifton 78, released in 1984. Compared with Coastal bermuda in replicated pastures for 3 years, Tifton 78 gave 13% better ADGs and 36% more LWG/A than Coastal. Fertilized with 150 lbs of N/A/yr. and adequate P & K, Tifton 78 averaged 877 lbs. of LWG per acre per year, 70 times more than the native range could have produced. The fertilizer cost was 5¢ per pound of LWG.

Discovery of a sexual plant of buffelgrass, *Cenchrus ciliaris*, enabled E. C. Bashaw to develop more-winterhardy apomictic cultivars, Neuces and Lano, that yield 25 to 35% more than common buffelgrass.

Nine cycles of recurrent restricted phenotypic selection applied to Pensacola bahiagrass produced Tifton 9, released in 1987. Compared with Pensacola bahiagrass, it establishes easier, is equal in quality, and has yielded 47% more forage in a 3-year seeded plot test.

Tall fescue, *Festuca arundinacea*, occupying some 35 million acres in the U.S., is the most important cool season grass in the South. Alta and Kentucky 31, released in 1940 and 1942 are standards of comparison in tall fescue evaluation. Mozart, released in Missouri in 1984, is free of fungal endophyte and as a result, has given about 30% better ADGs. Endophyte-free Au Triump developed at Auburn, Alabama in a 3-year grazing study supplied better fall and winter grazing and produced 12% more beef per acre than endophyte-free Kentucky 31. Removing the endophyte has improved the performance of animals grazing tall fescue but has left it more susceptible to insect injury and adverse environmental conditions. Other named cultivars have been developed.

Progress has also been realized in the development of improved pasture and forage legumes. A few examples follow. Regal and Tillman white clover, *Trifolium repens*, cultivars released from Alabama and South Carolina in 1962 and 1965 followed Louisiana S_1 released in 1952. All were 5 or 6 clone synthetics.

Dixie crimson clover, *Trifolium incarnatum*, a synthetic developed cooperatively by the USDA and several southern states, was released in 1946. Other cultivars named Auburn, Autauga, Tallalega, Chief and Tibbee came later.

Serola and Interstate serecea lespedeza, *Lespedeza cuneata*, developed in Alabama and released in 1962 and 1970, are better quality forages than common serecea because they have finer stems. Au-Lotan developed in Alabama and released in 1980 contains only half as much tannin, averages 27% higher digestibility and is 7% higher in crude protein than other cultivars at the hay stage.

Florida 77 alfalfa, *Medicago sativa*, with greater pest resistance and longevity in the deep South is the product of years of recurrent mass selection by Earl Horner at the Florida Agricultural Experiment Station.

Most of the virgin sandy soils in the Southeast are so deficient in plant nutrients that they will grow little more than pine trees and palmettos without fertilizer. On such soils, the forage and pasture plants just described will

not grow without fertilizer. The results of many fertilizer experiments were required to permit these improved cultivars to produce forage efficiently. When such research indicated, for example, that a 4-1-2 ratio of N, P_2O_5 & K_2O with some N from ammonium sulfate to supply sulfur and magnesium from dolomitic lime would permit optimum growth of bermudagrass, farmers were able to save money that would have been spent for phosphorus and potash in the 4-12-4 fertilizer generally used before that research.

Many management experiments were required to realize the full potential of the improved cultivars. When heifers fed Coastal bermudagrass hay cut at 4, 8, and 13 week intervals without supplement made ADGs of 1.2, 0.8, and 0.0 pounds, we learned that grass should be cut as frequently as alfalfa to produce quality hay.

About half of our time across the years has been spent learning how to establish, fertilize and manage our improved cultivars to help them succeed on the farm. Without that research and the time we spent answering questions about them, they would never have gone far beyond the bounds of the Georgia Coastal Plain Experiment Station.

Measuring pasture and forage crop progress from where we started in 1936, we must conclude that southern research workers have made great progress on the experiment stations. We've made similar progress on a few farms. On many farms, progress is far below where it could be. Putting it there is one of many tough problems yet to be solved. Their solution will demand the cooperation between all of us, particularly animal and plant scientists that SPFCIC fosters.

THE FUTURE FOR PASTURE AND FORAGE CROPS

Ted Bingham[1]

The future will be discussed from the standpoint of what to expect from genetic engineering and biotechnology. Most points relate to crop plants including pasture and forage plants. Attempts to predict the future are based on the experience and opinions of the author.

First, let us examine the impact of molecular methods and biotechnology on basic research in plant breeding from 1980 to the year 2000. In 1980 things were just getting started. The production of DNA from RNA by reverse transcription had been discovered, and the potential of recombinant DNA in gene cloning and genetic engineering was receiving a great deal of publicity. There was an explosion of new molecular research in both public and private sectors between 1980 and 1990. Currently we estimate that the percentage of basic research in plant breeding that involves molecular or biotechnology techniques is about 60%. Moreover, we believe that it will continue to rise and reach 85-90% in the year 2000. Included in the basic research are several uses of restriction fragment length polymorphisms (RFLPs); genetic transformation, ELISA and monoclonal antibodies for disease detection, genome mapping and many other DNA methods. Methods based on DNA are expected to remain important because of the fundamental nature of DNA. DNA contains the information about life itself and it will stay in fashion. And, there is still much to learn. We don't know why there is so much DNA in plants; we don't know what all the DNA is doing; we don't know how it is organized on chromosomes. We still don't understand the genetics of the sexual process including chromosome pairing, and importantly we don't understand the molecular basis of recombination in higher plants. Hence, there is much left to learn in the area of basic research in plant breeding using DNA methodology.

What about the impact of molecular methods and biotechnology on applied research in plant breeding? Much has been said about the expected impact, but what has actually happened? Several plants have been transformed including alfalfa, but there is nothing on the farm in 1990. By the year 2000 we believe that some biotechnology products will be on the farm or close to being on the farm. However, we further believe that these products will make up no more than 10% of the products. The other 90% will be from traditional breeding. This is because of the wealth of materials most plant breeders have to work with coupled with the efficiency of traditional plant breeding methods. There is tremendous power and efficiency in breeding for yield, for example. Basing selection in plant breeding on an end-product such as yield using equipment as simple as a scale is predicted to win-out over more expensive and complicated techniques even in the year 2000.

In 1983 I made a statement on the future of plant breeding for Touchstone magazine. Seven years have past and the statement remains true. I will make the same statement in 1990 and see what happens in another seven years. I predict that the world-wide army of traditional plant breeders will continue to account for nearly all crop improvements in the foreseeable future.

In summary, I predict that basic research using molecular methods is going to continue to generate knowledge of great value to plant breeders. Some of this knowledge will be used in new breeding strategies and in modifications and improvements on existing strategies. The current focus on quantitative trait loci using RFLPs is going to give us a basic understanding of the number and expression of genes controlling quantitative traits. Everyone will

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benefit. Transformation already has taught us that we don't know the product of many of our important genes. Knowing the product is a necessary first step in finding, cloning and using an important gene in transformation. Then, through transformation, it is possible to learn about the expression and interaction effects of genes. This knowledge will be important whether or not the transformation product ever becomes a cultivar.

Traditional plant breeding is more efficient than many people realize and I predict that most crop improvements will continue to be made using traditional breeding methods. Moreover, these traditional methods will be made more powerful by new basic knowledge from molecular and biotechnology research.

PERSISTENCE IN FORAGE SYSTEMS

J. H. Bouton

When selecting forage species for use as perennial pasture in the Southeastern USA, the following statements would represent the guidelines used by most forage-livestock producers:

> Persistence is the most important characteristic a pasture species can possess.
>
> Legumes are less persistent than grasses.
>
> Cool season perennial grasses are less persistent than warm-season grasses in hot, humid areas.
>
> Tall fescue is the most persistent cool season perennial grass species.

Since perennial pastures comprise the major forage acreage in the region, these guidelines have become dogma and demonstrate the emphasis placed on persistence. Therefore, what has evolved are permanent pastures predominated by perennial grasses; bermudagrass or bahiagrass in the southern one-half of the region and tall fescue or tall fescue-bermudagrass in the northern half. Management of these perennial grass systems consists mainly of fertilization (primarily nitrogen), continuous grazing, hay production of surplus grass, and hay feeding during the off-season. The major livestock production system which has evolved to fit these perennial grass systems is "cow-calf".

Although these grass systems are very persistent, they do suffer two major weaknesses; an off-season season where they produce little or no forage and poor quality during a major portion of their productive season. Over the years, much of the forage management and cultivar development research has centered on studies to overcome the weaknesses of the perennial grasses themselves or the non-persistent legumes and grasses. An example of each would be breeding and management studies to improve the quality of bermudagrass and the regional project to overcome the viruses of white clover, respectively.
For the purposes of discussing persistence of forage systems for this paper, we will concentrate on the following scenario: The perennial grasses form a baseline that is dependable and persistent. What is needed are persistent legumes and "off-season" grasses which ecomonically fit into these systems and overcome their weaknesses. Since this is the philosophy of our forage breeding program, the examples which will be used to demonstrate what strategies can be employed are the two being investigated in Georgia; the development of tall fescue as perennial pasture for
use in the southern coastal plain and the development and use of alfalfa as an intensely grazed, pasture crop.

TALL FESCUE FOR THE SOUTHERN COASTAL PLAIN

The southern coastal plain possesses long, hot, and often dry summers. Insect, disease, and weed pests are prevalent. Aggressive warm season grasses predominate,

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and as stated above, are the main species found in permanent pastures. However, there is still a winter period where these warm season species are not productive causing farmers to incur the cost of feeding mainly poor quality hay. What is needed are temperate, perennial species which can withstand the inherent stresses yet provide winter grazing. Although farmers have tried unsuccessfully over the years to grow tall fescue in the region, its reputation as a persistent species made it a good candidate for use in breeding programs to develop persistent types.

The breeding strategy used was to expose parental tall fescue populations, mainly 'Kentucky 31', to the natural stresses of the region in conjunction with grazing. Surviving plants were selected from the pastures and further selected for yield. These selected genotypes were then used as parents to develop three germplasms; Georgia-5, Georgia-Jesup, and Georgia-Jesup Improved. During extensive regional testing, these germplasms were found to be more persistent than Kentucky 31 and 'AU Triumph'. They were also found to be infected with the tall fescue endophyte. Subsequent experiments showed the endophyte was responsible for each germplasm's persistence (J. H. Bouton, unpublished data).

Is there a place for endophyte infected tall fescue in the region? To answer this question, a grazing study was begun in cooperation with Roger Gates, USDA-ARS, and Garry Hill, Animal Science Dept., Coastal Plain Exp. Stn., Tifton, Georgia to investigate the performance of infected Georgia-5 tall fescue when sod seeded into 'Pensacola' bahiagrass and 'Coastal' bermudagrass. The mixed plantings were chosen because they provided a low cost method (ie. less land) to achieve a year round grazing system and would adequately measure the stresses likely to be encountered in the real world. The criteria used to measure success were (1) will infected Georgia-5 persist in this grazing system and (2) would cattle gain or at least maintain body weight with limited hay feeding and show no toxicity symptoms. The results for one season have shown good summer survival and significant winter gains with no hay feeding (R. Gates and G. Hill, unpublished data). This experiment will be continued so long term persistence can be assessed.

GRAZING TOLERANT ALFALFA

Beef cattle are the primary livestock group in the southeastern US. Georgia, for example, has 1.5 million beef cattle, but only 100,000 dairy cattle. Since alfalfa has never been a major forage in southern beef cattle operations, yet nutritional problems continually plague these producers, then incorporation of alfalfa into current forage systems should be a major goal for the region. This will require using alfalfa in "nontraditional" ways. It will need to assume the roles not only of hay and silage crop, but also of direct grazed forage which is often overgrazed and even that of renovation legume in grass pastures. Therefore, if alfalfa could be used as a intensively grazed pasture plant, heretofore not one of its uses, its overall use would certainly be enchanced.

Creeping rootedness was thought to be the trait necessary to confer grazing persistence to alfalfa. The association of this trait with poor yield and the inability to see a true "creeping" growth habit were

problems in developing grazing type cultivars. Our breeding approach at the University of Georgia, therefore, was to expose broad based parental populations to intense, continuous grazing pressure and recurrently select good genotypes for two cycles on the basis of persistence. At the end of the second cycle, 30 parental plants were selected and these polycrossed with seed of 19 bulked to produce the syn 1 generation. This germplasm was identified experimentally as GA-GC or Georgia-GC and was found to be much more persistent under continuous grazing than other cultivars tested yet was similiar in yield, palatibilty, and animal performance (Smith, et al., 1989; C. S. Hoveland, unpublished data). It has recently been released under the name 'Alfagraze' and is intended for use in the east central and southeastern US for grazing, hay, and silage production.

SUMMARY

Persistence is the most important trait a forage species can possess. The importance of persistence has resulted in southern forage systems being predominated by perennial grasses which are very dependable under heavy grazing. In the two examples of developing tall fescue and alfalfa for use as part of these heavily grazed, stressful pasture situations, persistence was the main criteria during their selection with the breeding strategy being to expose parental populations to heavy grazing pressure in combination with the natural climatic and soil stresses of the region. The results were development of experimental germplasm, and in the case of alfalfa, a new cultivar which are very persistent.

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Smith, S. R., Jr., J. H. Bouton, and C. S. Hoveland. 1989. Alfalfa persistence and regrowth potential under continuous grazing. Crop Sci. 81:960-965.

LEGUME BREEDING AND EVALUATION AT THE UNIVERSITY OF KENTUCKY

N.L. Taylor[1]

HISTORICAL

Legume breeding at the University of Kentucky began in the 1930's with Dr. E.N. Fergus who conducted practically all the forage research including breeding of red clover (Trifolium pratense L.) (Taylor, 1985). About 1940, he was joined by Mr. Lawrence Henson, plant pathologist, and in 1947 they released the red clover cultivar Kenland, which is maintained to the present. These researchers were joined in 1953 by the author of this presentation, and cooperatively with the U.S. Department of Agriculture, the breeding research was greatly expanded.

GOALS

It was agreed with Dr. E.A. Hollowell (USDA-ARS) (Taylor, 1985) that the primary aim of the program would be to develop cultivars with greater persistence than those available at that time. A secondary goal was to gain an understanding of the factors involved in persistence of red clover. It was generally considered that diseases were the main causes of the short life of red clover, and great emphasis was to be placed on genetics, breeding, and mechanisms of disease resistance.

Poehlman (1979), in his textbook on breeding field crops singled out forage crop breeding as being particularly difficult. It is the objective of this paper to relate experiences involved in the breeding of forage legumes, to examine procedures whereby the difficulties considered by Poehlman were dealt with, if not overcome; and to draw specific conclusions concerning the success of the various programs. The number of species under investigation was increased over time and the breeding objective for each is given in Table 1. Persistence (longevity) is the general theme of all programs, although pest resistance, and seed and forage yield were given much consideration.

ACCOMPLISHMENTS

The general practice was to investigate a particular breeding procedure and to release the developed plant materials in the form of germplasms (Table 2) if the material needed further development. Otherwise, it was released as a cultivar. However, germplasms include gene markers and other genetic stocks that were never considered for release as cultivars.

Breeding methods with advantages and disadvantages as used in Kentucky are given in Table 3.

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Table 1. Objectives of breeding programs by species.

Crop	Scientific Name	Objectives
Red clover	*T. pratense*	Greater persistence and yield for hay, pasture and silage.
Red clover (interspecific hybridization)*	*T. pratense*	Greater persistence and yield for hay, pasture and silage.
Kura clover	*T. ambiguum*	Greater seedling and aftermath vigor for pasture.
Zigzag clover	*T. medium*	Greater seedling and aftermath vigor for pasture.
White clover (interspecific hybridization)**		Greater virus disease resistance and persistence for pasture.
Winter annuals		Greater winter hardiness

* *T. pratense* X *T. sarosiense*
** *T. ambiguum* X *T. repens*

Table 2. Germplasms and cultivars released from the Kentucky program.

Crop	Release Identification
Red clover	Kenland, Kenstar, 28 GP.
Red clover hybrids	With *T. diffusum*; *T. sarosiense*
Kura clover	Rhizo,* Ky 1 GP.
Zigzag clover	Ky M-1 GP.
Zigzag clover hybrids	With *T. sarosiense*; *T. alpestre*(GP.)
White clover hybrid	With *T. ambiguum* GP.
Crimson clover	Ky C-1 GP.
Alfalfa	Ky V-1, Y-1, Z-1 GP.
Sericea lespedeza	Appalo*

* Cooperative with Soil Conservation service, Quicksand, Kentucky.

Table 3. Advantages and disadvantages of forage legume breeding methods as used in the Kentucky program.

Breeding method	Advantage	Disadvantage
Polycross method -(red clover)	Progeny testing	Slow, difficult to maintain clones
Doublecross hybridization (red clover)	Hybrid vigor, uniformity	Parental lines difficult to maintain; difficult to isolate high combiners
Phenotypic recurrent Selection		
a. Crimson flower color(Red clover)	Rapid	Inbreeding depression
b. Stem length (red clover)	Rapid	Loss of persistence, Inbreeding depression
c. Multiple-parted head	Rapid	No increase in seed yield
d. Vigor (zigzag clover)	Rapid	Selection ineffective
e. Vigor (kura clover)	Rapid	Inbreeding depression
Backcross breeding		
Mildew resistance (red clover)	Easy	Slow, inbreeding depression
Virus resistance (red clover)	Easy	New virus appeared

CONCLUSIONS REGARDING BREEDING METHODS

Although the polycross method used in the development of Kenstar red clover was effective (Taylor and Anderson, 1974), it required about 13 years. Phenotypic recurrent selection is probably more effective than the polycross method because more cycles of selection can be conducted in a given period of time (Cornelius and Taylor, 1981). For persistence, three years per cycle are needed, so that in 13 years, 4 cycles of selection would have been possible. Due to lack of progeny testing it is possible that some escapes will be selected, but these can be eliminated in the next generation. The main difficulty with this method is inbreeding, which may occur if the number of plants selected is too few. Also correlated change in characters may be a problem. For example, selection for increased stem length resulted in more upright crowns and less persistence in red clover (Bowley et al., 1984).

Doublecross hybrid breeding is a laudable ambition because of utilization of hybrid vigor, but it is difficult in red clover to maintain parental lines, and even more difficult to isolate high combining lines (Andersen et al., 1972). Most clover breeding programs are not sufficiently funded to allow the extensive testing necessary to isolate clones with high specific and general combining ability.

Backcross breeding was used to introduce mildew and virus resistance into Kenstar red clover (Taylor et al., 1985). However, phenotypic recurrent selection probably would have been better procedure for this objective for three reasons: (1) sufficient variability for resistance existed within Kenstar, (2) opportunity existed for selection of other characters, and (3) inbreeding depression could have been avoided (Taylor et al., 1985).

In addition to the standard methods of breeding, methods have been employed to increase genetic variability: Tetraploidization, interspecific hybridization, irradiation, and genetic engineering (Table 4).

Tetraploid breeding has resulted in red clover cultivars in Europe and New Zealand that are higher yielding and more disease resistant than diploids. However, due to low seed yield, and high seed costs they are not used extensively by farmers. In the United States, tetraploids are less vigorous and yield less forage than diploids (Taylor et al., 1975), possibly because of a lack of heat stress tolerance.

No interspecific hybrids of forage legumes have been released as cultivars (Taylor et al., 1963; Phillips et al., 1982). Possibly one of the best hopes is the _T_. _ambiguum_ X _T_. _repens_ hybrid, which is fertile. This hybrid, however, is susceptible to peanut stunt virus, and perhaps other viruses. Additionally, no clear-cut character criteria are available for selection in segregating and backcross populations. Nevertheless, this hybrid merits further research.

Table 4. Methods of generating variability in forage legumes at Kentucky.

Method	Advantage	Disadvantage
Tetraploid breeding		
Colchicine	All types of material	Low percentage effectiveness
Nitrous oxide	Highly effective	Only seed propagated types
Gametic non-reduction	Supposedly highly vigorous	Need tetraploid to start
Interspecific Hybridization		
_T_. _pratense_ X _T_. _diffusum_	Highly fertile	Less perennial than red clover
_T_. _sarosiense_ X _T_. _pratense_	Perennial	Sterile
_T_. _ambiguum_ X _T_. _repens_	Moderately fertile	Intermediate and susceptible to virus
Irradiation	Select for single character	Useful only for self pollinated species
Genetic engineering	Fast, useful for single characters	Not for polygenic characters

Irradiation was used at Kentucky to increase the amount of self-fertility in red clover (Taylor et al., 1961). It proved to be impractical due to the cross-pollinated nature of the species and because, contrary to information in the literature, self fertility is a variable character in red clover.

Genetic engineering has been moderately successful in clover breeding at Kentucky. First, we were able to rescue hybrid embryos from the cross of Trifolium sarosiense X T. pratense (Phillips et al., 1982). These species are genetically widely separated and cannot be mated successfully by conventional means. However, the hybrid is sterile, both at the diploid level and when the chromosome number is doubled, and backcrosses, even with embryo rescue are difficult (Mousett-Declas et al., 1989). Somatic fusion of cells of parental clover species has been unsuccessful. Another application of genetic engineering was in vitro selection of somaclones for ability to grow under minimal levels of phosphorus. Regrettably, somaclone whole plant performance was not related to in vitro performance (Bagley and Taylor, 1987).

In conclusion, we have seen that the techniques of tetraploidization, irradiation, interspecific hybridization and, so far, genetic engineering have resulted in no new forage legume cultivars. These methods have been a useful adjunct to forage legume breeding but it is doubtful that any of these techniques can replace classical breeding methodology.

How soon will we see the advances of genetic engineering incorporated into forage legume varieties? At the recent International Grassland Congress in Nice, France, 127 papers on forage breeding from 76 countries were presented. Ten papers, or less that 8 percent dealt with molecular genetics and most of these were reports of early stages of tissue culture. Due to lack of funding on forage legumes, it is expected that the first advances in genetic engineering will be made with the major food crops; maize, wheat, soybeans, rice, and with tobacco. After the protocols have been developed for these crops, they may be adapted for the improvement of forage legumes. Therefore it is unlikely that improvements resulting from genetic-engineering will be in place at the farm level before the early years of the next century,

GENERAL PHILOSOPHIES CONCERNING FORAGE LEGUME BREEDING

The question may well be asked: which methods are the most successful for forage legumes? The answer is: the procedure that is used first, and usually that is a very simple procedure. It may be even the multiplication of natural ecotypes. The earliest research at a particular location has the opportunity to utilize much of the genetic variability that is available. Kenland red clover is a good example. It was bred for persistence using the simplest of methods; recurrent mass selection with control of pollination--very similar to phenotypic recurrent selection. Seeds of the most highly adapted ecotype were sown, plants inoculated with disease-producing organisms, susceptibles eliminated and, after further natural selection, seeds were harvested for another cycle of selection. After several cycles the cultivar was released and seed was maintained from third-year stands thereafter. It has proved very difficult to develop a cultivar superior to Kenland red clover in its area of adaptation. We conclude that the breeding program increased adaptability as well as disease resistance, and that in many situations, the two are related.

Genetic gain in yield from breeding of maize, rice, wheat, sorghum and soybeans is well documented. Comparable genetic gains have not been demonstrated for forage legumes. The difference may be that fewer researchers are involved in the breeding of the many different forage crops; but another reason may be that the economic product is forage rather than seed. In forage crops, no possibility exists to increase forage yield at the expense of seed yield. We have seen that low seed yield in a forage cultivar will mitigate against its use in the seed trade.

What genetic gains have been made in forage legumes? Most forage legumes, being fairly high in quality, have not needed further improvement. On the other hand, selection for pest resistance has been a high priority. This has resulted in increased assurance of yield, but has little effect on higher potential yield.

In the last 30 years several new major forage legume cultivars have been released for use in Kentucky (Table 5). The cultivars of the "major" legume species have mostly been successful. But, for the minor crops, the new cultivars have thus far been unsuccessful, suggesting that it is extremely difficult to introduce a new crop (or cultivar) because the old crop, particularly if a perennial, must be dislodged or replaced to a certain extent. Therefore, the new entry must be outstanding in most respects and have no major shortcomings. Rhizo kura clover is an example. It is outstanding in vegetative spread, disease resistance, and perenniality and seems ideally suited to be a valuable addition as a pasture legume. However, it lacks seedling and aftermath vigor and thus does not meet the criteria to be extremely successful. It likely will not replace either white or red clover. Overcoming this deficiency by breeding will not be easy, and if accomplished at all it is likely to require many years of effort. The public may not be of a mood to fund such programs in a time of agricultural surpluses. Instead, the more exciting "flashy" research likely will be funded, at least until the agricultural surpluses are depleted.

Table 5. Introduction of new forage legume cultivars

Crop	Cultivar	Success
Red clover	Kenland, Kenstar	++++
White clover	Regal, etc.	++++
Alfalfa	Many	++
Annual lespedeza	None	+++
Big flowered vetch	Woodford	-
Birdsfoot trefoil	Fergus	-
Sericea lespedeza	Appalo	+
Kura clover	Rhizo	?

PRESERVATION AND INTRODUCTION OF FORAGE LEGUME SPECIES

Recently, considerable interest has been generated in the preservation of plant species. This has led to the establishment of crop curators to aid the plant introduction stations located in each major region of the United States. At Kentucky, we have responsibility for Trifolium (clover) genus. This collection has been maintained since the early 1950's and now consists of seeds of about 225 species. The activities of the curator involve (at least at Kentucky) exploration, collection, evaluation, maintenance, increase, enhancement, classification and distribution.

Exploration and collection locations have included: Eastern United States, Rocky Mountains, California, Romania, Yugoslavia, New Zealand, Australia, and Sweden. Romania and Yugoslavia were formal explorations funded by the Plant Introduction Service. By these explorations, contact at annual meetings and by correspondence, seeds have been added to the collection that now is the world's largest in number of species, but only a few accessions per species are generally available. Several conclusions may be formulated.

1) The list of Trifolium species is not complete and probably never will be because of synonony (disagreement among authorities as to what constitutes a species).

2) Species are evolving, and at the same time becoming extinct. Several species that have been described can no longer be found.

3) Genetic vulnerability is not a problem because considerable hidden variability exists, particularly within the cross-pollinated species.

4) Some species have not been discovered.

CONCEPTS CONCERNING PERSISTENCE OF FORAGE LEGUMES

One of the original objectives of these investigations was to gain an understanding of the factors involved in persistence of red clover. Perhaps the use of the term "concepts" is more appropriate than "factors". Regardless, some understanding, hopefully, has been achieved. In the 1978 Forage Crop Improvement Conference held in Sarasota, Florida, a working concept of persistence was presented (Taylor et al., 1978) and is reproduced here (Fig. 1).

In this concept, a species of plant or animal has given life span that is influenced by its environment, and may be modified to a certain extent by breeding. Thus, it is inappropriate to state that the short life span of red clover is caused by susceptibility to pests; rather the short span is the result of the physiology of the species. Red clover, as shown in Fig 1 may live up to five years or so in favorable environments and less in unfavorable environments, in much the same manner as the life span of Homo sapiens is regarded to be about 70 years. This does not mean that nothing can be done. On the contrary, the environment may be amended, and the plant may be modified within limits by breeding. In plant species, we also have the possibility of developing, via interspecific hybridization, species which in turn will have a newly determined life span.

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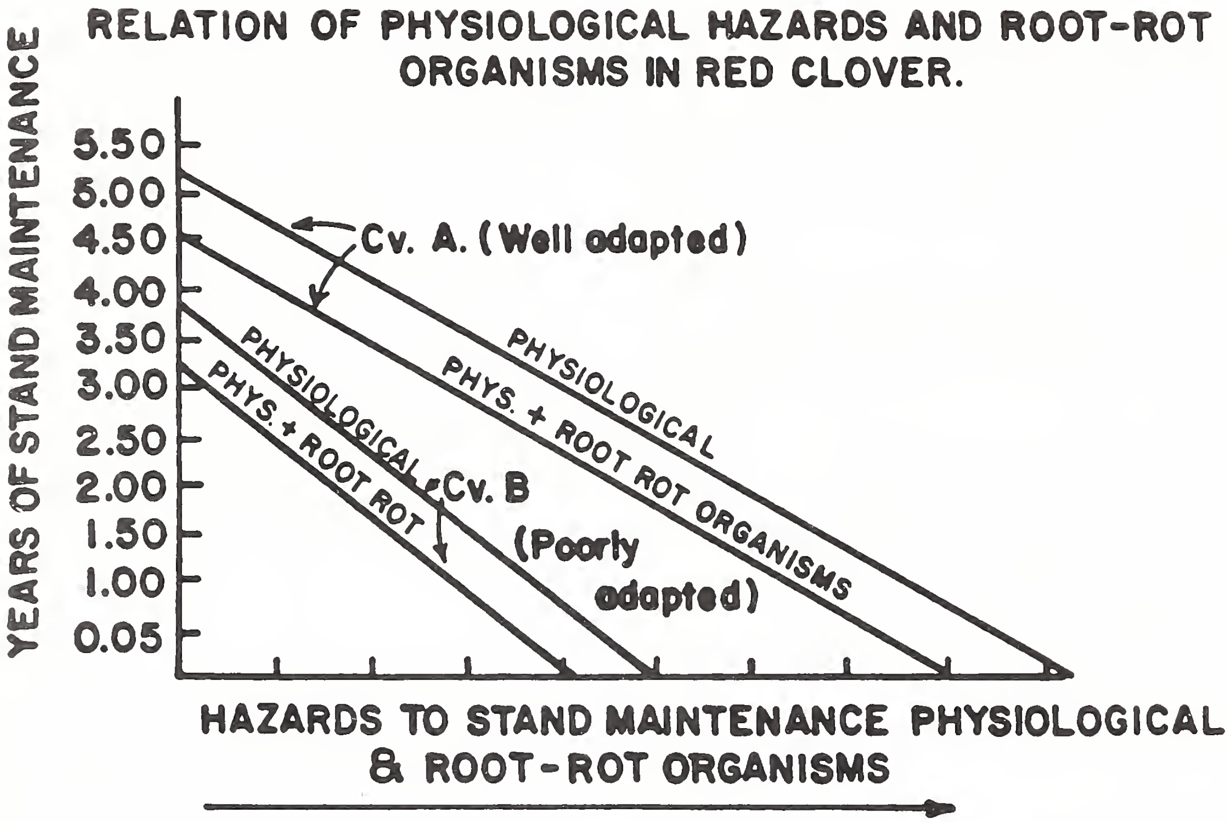
FIG. I


RELATION OF PHYSIOLOGICAL HAZARDS AND ROOT-ROT ORGANISMS IN RED CLOVER.
YEARS OF STAND MAINTENANCE
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.05
Cv. A. (Well adapted)
PHYSIOLOGICAL
PHYS. + ROOT ROT ORGANISMS
PHYSIOLOGICAL
PHYS. + ROOT ROT
Cv. B
(Poorly adapted)
HAZARDS TO STAND MAINTENANCE PHYSIOLOGICAL & ROOT-ROT ORGANISMS

GRASS BREEDING AND EVALUATION IN NORTH CAROLINA

D. H. Timothy

I was asked to give a brief generalized overview without data of our program from its inception to where we are, including some of the research problems and opportunities as well as various administrative thoughts, viewpoints, understandings and agreements.

The North Carolina Experiment Station program had been initiated earlier on orchardgrass and tall fescue. I had the freedom to work in any promising area and change genera if justifiable. I arrived too late to plant so had ample time to read, think, and talk with colleagues. Efforts of the US colonists of several hundred years and recent breeding efforts to adapt orchardgrass and tall fescue further south and obtain desirable production were not successful. However, we evaluated all the diploid subspecies of orchardgrass, their hybrids and doubled hybrids. These looked promising but not sufficiently adapted. We also began evaluating hundreds of perennial warm season accessions (mostly from Asia, Europe, North Africa, and the U.S.). Performance requirements were near-complete winter survival, early and vigorous spring growth, and high forage production. _Panicum virgatum_, _Pennisetum flaccidum_, and _P. orientale_ (later discarded because of inadequate winter survival) were chosen for study.

The rationale for the approach was that the 60° isotherm (demarking the adaptability of cool- or warm-season grasses) runs through the state. Temperature and rainfall patterns coincide with warm-season growth curves. Moreover, ecological factors and evolutionary history indicated that certain warm-season genera might perform better in the transition zone, parallelling the 60° isotherm, and further south than would the cool-season grass. Moreover, of the 320 species of grasses in N.C. representing 13 or the 14 tribes, 97 belong to Panicum.

Simple in vivo and in vitro digestion and cafeteria grazing trials indicated that flaccidgrass and switchgrass would be suitable. The USDA position was filled by J. C. Burns and we began small grazing experiments of both species and also using in vitro digestion on individual plants in the lowland forms of switchgrass in all cycles of half-sib selections.

Difficulties in obtaining in an orderly and timely manner the suitable land for grazing experiments, machinery and farm equipment, fencing, irrigation facilities, hay and silage storage, suitable animals, lab space and equipment were frequent and repetitive. Because of these deficiencies many experiments were lost and our progress was seriously retarded, perhaps by 6 to 8 years. We each operated as if our funds were co-mingled, often to the consternation of our administrators. The regulations for the expenditure of state or federal funds are distinct. We presented our programs as parts of a continuum and unified effort at every opportunity. Eventually our administrators recognized we operated jointly as a team and they more readily accommodated our needs, although each new one had to be "trained." At times we operated as though we had been given tacit approval, at others we needed verbal responses, formal memoranda of agreements or understanding, or research support agreements. Each agency had distinct criteria for evaluation, but the systems basically are not much different from an intramural system. However, the state system seems to pay somewhat less attention to order of authorship than does the federal system. The former probably is able to recognize a more realistic appraisal of each individual's role and contribution to the group effort than the federal system.

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We have released the cultivar 'Carostan' flaccidgrass, are in the final 2 years of evaluating 6 switchgrass synthetics for release, and will begin testing 4 other switchgrass synthetics in 1991. In addition to our work being predicated upon vigorous spring growth, high forage yield and IVDMD, and good animal response with grazing, we tried to determine what contributes to forage quality. These factors have included simple and complex sugars, cell wall composition, particle size, rates of digestion, rates of passage, etc., on initial growth and various regrowth stages. (D. S. Fisher and K. R. Pond are also involved in these later studies).

For breeding it would be useful to have a more rapid, simpler, less expensive evaluation than the usual IVDMD procedures for more rapid and greater progress in selection. As yet, we have no alternative.

The experience has been interesting, difficult and at times exasperating, fun, and educational. I am convinced that our separate areas of expertise in this cooperative effort have contributed to a sounder, more enlightening and productive program than could have been obtained otherwise.

RESEEDING ANNUAL CLOVERS IN PASTURES - EFFECTS OF HARDSEEDEDNESS AND MICRONUTRIENTS ON ESTABLISHMENT OF RESEEDING STANDS

G. R. Smith

INTRODUCTION

The maintenance of reseeding winter annual clover stands is dependent on seed production, seed survival and seedling establishment. This paper will discuss some aspects of seed survival as influenced by hard seed. The apparent role of boron in clover seedling establishment will also be discussed.

SEED SURVIVAL

Annual plant species are dependent on seed survival for their continued existence. Mature seed must be capable of enduring adverse climatic conditions and germinate when the environment is favorable for plant growth and reproduction. Hard seed is a critical trait that affects seed survival of annual clovers.

Hard Seed

Initial hard seed percent at seed maturity, rate of hard seed softening, and buildup of soil seed banks are three components of the expression of hard seed characteristics in annual clovers. Annual clover species vary widely in their ability to produce hard seed. This paper will deal primarily with subterranean clover (*Trifolium subterraneum* L.), berseem clover (*T. alexandrinum* L.), and rose clover (*T. hirtum* All.).

Both plant genotype and environment affect the level of hard seed production in subterranean (sub) clover. However, recent studies indicate that environmental effects may be more important than previously recognized (5). The rate of hard seed breakdown is also dependent on both plant genotype and environment (5, 8). Extremes of soil moisture availability during sub clover seed maturation can adversely affect hard seed production and rate of softening. At one of five California sites, the hard seed level of 'Mt. Barker' sub clover declined slowly with 38 percent hard seed recorded in October (9). The remaining four sites were low in soil moisture during seed maturation and the hard seed level dropped rapidly until all seed were permeable in October. In Mediterranean climate regions (wet mild winters-dry hot summers) low soil moisture after flowering limits sub clover hard seed development (4). Both a long seed development period and a high degree of drying after maturity are required for optimum development of high quality hard seed in sub clover (1).

Thirty-three sub clover lines, including 14 registered cultivars, were evaluated for reseeding at Angleton and Overton, Texas over a 2-1/2 year period (2). Summer and fall germination in the first reseeding year depleted 70 to 99 percent of the seed crop from the sub clover cultivars evaluated. Mt. Barker and Woogenellup germinated over 96 percent of their seed crop in this first summer and fall period. Results from this study indicates that one adverse fall season with several stand failures would eliminate most sub clover cultivars from the pasture system. The cultivars Meteora and Esperance were marginally better than other cultivars in second year reseeding at Angleton and Overton, respectively. Several breeding lines with better apparent reseeding were also identified.

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Mt. Barker, Mississippi Ecotype, and several experimental sub clover lines were evaluated for hard seed production and rate of softening over three seed production years at Overton (6). In 1984 and 1985, most lines produced 60 percent or more hard seed. In 1986, possibly due to high soil moisture during seed maturation, many lines exhibited a sharp drop in initial hard seed level. Rate of hard seed breakdown was influenced by production year and plant genotype. Seed production environment set the upper limit for hard seed level, but plant genotype determined rate of hard seed softening. Sub clover breeding lines with more persistent hard seed than Mt. Barker were identified.

Berseem clover is generally considered non-reseeding, but selections made from reseeding stands of 'Sacromonte' produced the new cultivar 'Bigbee'(3). In 1987 at Overton, TX, Bigbee produced 40% hard seed at harvest but hard seed level declined to 5% after exposure to 90 days of summer temperatures (7). In the same study, berseem hard seed selections produced 67% impermeable seed at harvest which declined to 34% after 90 days. Recurrent selection with progeny testing was successful in improving both initial hard seed levels and decreasing the relative rate of softening of berseem hard seed.

Rose clover produces a high percentage of very persistent hard seed. Ten breeding lines and three cultivars of rose clover were evaluated for hard seed production and rate of softening at Overton, Texas for three years. Average hard seed at harvest was 80% and after 90 days at summer temperatures the average hard seed level declined to 72% (G.R. Smith, unpublished). Rose clover reseeding should not be inhibited by seed survival.

The presence of seed capable of germinating does not always ensure a productive stand of annual clover. After germination, other factors affect establishment, including soil fertility.

BORON EFFECTS ON CLOVER ESTABLISHMENT

Soils in the East Texas Timberlands are often sandy and acidic with low native fertility. Phosphorus and potassium fertilization and liming are generally necessary for annual clover forage production. Boron fertilization has been recommended but has not been used in recent forage fertilization programs. Field experiments at Overton have shown improved maintenance of reseeding annual clover stands when boron deficiencies were corrected. Research was conducted to evaluate the effects of boron on seedling establishment of annual clovers and to evaluate the relationship between seedling drought tolerance and boron amendments.

The pH of the Lilbert loamy fine sand used in these greenhouse experiments was 5.5. Potassium, phosphorus, and calcium levels were adjusted according to soil test. The soil was air-dried, screened through a 0.25 in. screen, mixed, and weighed into individual 6-in. plastic pots, each receiving 4.8 lbs of soil. Mineral amendments were added on a soil weight basis. Soil boron content was analyzed before and after addition of fertilizer boron. In all experiments, boric acid was the boron source.

In the first experiment, seeding establishment of Mt. Barker sub clover was evaluated at 2, 3, and 4 weeks using three rates of boron fertilization. Native soil boron levels were 0.3 ppm B or less and the addition of at least 1.0 lb B/ac increased soil analysis B to 0.8 ppm. Correction of soil B deficiency caused corresponding increases in root and shoot dry weights. The increased root mass was due to increases in taproot length and number and size of lateral roots.

A second experiment was conducted to determine the effects of B on seedling survival of sub and rose clover under drought stress. Both species were planted in pots in the greenhouse under native (0.3 ppm B) and amended (0.8 ppm B) soil B conditions. After 10 days, no

water was added to the pots and death rate was recorded. Twenty-five percent of the sub clover in native (no B added) treatments were dead on day 21 (counted from emergence) and all had died by day 31. Boron amended sub clover did not begin dying until day 31 and all were dead by day 44. Similar results were noted for rose clover.

Our studies show that boron is crucial for annual clover seedling establishment, growth, and survival. Boron applied at 1.5 lbs/ac pre-planting resulted in dramatically larger plants under conditions of adequate water supply. Plants fertilized with boron were also more drought tolerant than unfertilized plants. These dramatic effects were the result of the correction of soil boron deficiency. The native boron level of less than 0.3 ppm B was corrected to 0.8 - 1.0 ppm by the addition of 1.5 lbs B/ac. Annual clover forage production depends on successful seedling establishment. Correcting boron soil deficiency before planting helps ensure greater seedling survival under drought conditions and improved early seedling growth and establishment.

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ENVIRONMENTAL INFLUENCE ON ESTABLISHMENT OF RESEEDING ANNUAL LEGUMES

Gerald W. Evers[1]

Cool-season annual forage legumes are used throughout the southeastern US. They are used primarily with warm season perennial grasses such as hybrid bermudagrass (Cynodon dactylon (L.) Pers.), bahiagrass (Paspalum notatum Flugge) and dallisgrass (Paspalum dilatatum Poir.) which form the basis of improved pasture systems in the Lower South. The primary advantage of incorporating a cool-season legume with a warm-season perennial grass is the higher forage quality of the legume which results in improved animal performance (Evers, 1989a; Hoveland et al. 1978). The peak clover growth period occurs in March and April which preceeds the summer perennial grass. This extends the graz-ing period which reduces the winter feeding period and the amount of stored forage needed. The earlier clover growth also provides some spring weed control for the grass through plant competition (Evers, 1983). Transfer of nitrogen fixed by legumes is also enhanced by the clover preceeding the grass (Evers, 1985).

Successful persistence of cool-season annual legumes in warm-season perennial grasses is dependent on 1) well adapted legumes, 2) good seed production the previous spring, 3) high hardseededness to avoid summer germination, 4) favorable temperature and moisture during desired period of emergence, and 5) reduced grass competition during legume emergence so light is not limiting. This paper will discuss topics 1, 4 and 5.

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ADAPTABILITY

The word "adaptability" has been around a long time when discussing improved forage production. It is mentioned so frequently that we in research and extension probably fail to stop and reflect on how important adaptability is. The better adapted a forage plant is, the less management and production inputs are required to maintain that forage plant. In other words, a well adapted forage will persist under less than optimum management and with few inputs. This goal is seldom achieved, but does make the point that selecting for adaptability may be equally or more important than yield. This is especially true now with the trend is toward low input, sustainable agricultural systems. Adaptability is most critical for forage legumes which are more soil specific (pH, texture, etc.) than grasses.

GERMINATION

Moisture is the initial requirement for germination but is seldom controllable under field conditions and therefore will not be discussed. Strand and Fribourg (1973) reported that environmental variables explained much of the variation in initial forage legume stands with temperature being the second most important after moisture. There have been several studies on the influence of temperature on clover germination (Elkins et al. 1966; Evers, 1980; Hoveland and Elkins, 1965; Knight, 1965). Such data is useful in determining optimum planting dates for various species. It can also identify the approximate time in the fall when a legume will volunteer if moisture is available. A producer can then manage his pasture to enhance legume seedling survival. Germination data reported in Table 1 indicates arrowleaf clovers (Trifolium vesiculosum Savi) should not be planted until October on the Gulf Coast. Soft seed of Abon Persian (Trifolium resupinatum L.) and crimson (Trifolium incarnatum L.) will germinate under summer temperatures. They may be poor reseeders if they do not have a high percentage of hard seed to prevent summer germination. Clover that germinates

during the summer months usually die. However, some legume species which germinate in August will survive until fall if periodic rainfall occurs to keep the soil moist and temperatures moderate. Most cool-season annual legumes have good germination at low temperatures, but germination rate is reduced. Lower temperatures also slow the rate of seedling development (Raguse et al., 1970).

LIGHT

The response of perennial legume seedlings to light is reported by Cooper (1977) in a review on growth of legume seedlings. Variations in light level were achieved in growth chambers or with different thicknesses of shading under natural sunlight. As light level decreased, top growth, root growth and nodulation decreased. Kalmbacher and Martin (1983) reported on the influence of light in establishing jointvetch (Aeschynomene americana L.) in bahiagrass. The highest joint vetch yields were obtained with the management treatments which allowed the greatest amount of light.

A greenhouse procedure was reported by Evers (1989b) on using varing lengths of PVC tubing on clover seedlings to simulate competition for light from various heights of neighboring plants. Tube sets were also placed on seedlings at different growth stages. Plant height increased at the 25.4 and 50.8 mm tube height but then decreased as tube height increased (Table 2). Leaf number, nodule number and plant weight demonstrated a consistent decrease as light became more limiting with increasing tube height. The response to growth stage at which the tubes were placed on the seedlings was not as dramatic as tube height with only plant height and nodule number being significant (Table 3). However, there was a general increase in all plant parameters as tube placement was delayed. The study points out the dramatic effect grass height has on emerging clover seedlings by limiting the amount of light which reaches the soil surface.

CONTROLLING GRASS COMPETITION

Grazing

The optimum method to manage grass competition to emerging clover seedlings during the fall is grazing. The pastures should be stocked heavy enough to keep the grass short until temperatures drop low enough to slow or stop grass growth. Young clover seedlings are harmed less by grazing cattle than if the livestock were removed and the grass continued to grow and shade the clover seedlings. The other advantage to grazing is that it requires no equipment or other costly inputs.

Hay harvest or mowing

Cutting and removing the grass for hay is another alternative. Livestock would have to be removed 4 to 8 weeks before the desired cutting date to allow accumulation of grass to justify a hay harvest. Limitations to this method are: (1) the hay crop may not be cut at the proper time because of poor drying conditions, (2) grass grown during August and early September is of low quality, and (3) and the grass will continue to grow after the hay cutting, and compete with emerging clover seedlings. The pasture can be mowed if there is insufficient grass for a hay harvest.

Chemical control

Glyphosate and paraquat are two desiccants which are cleared for pasture renovation. They have been more successful on temperate than tropical perennial grasses. Paraquat causes quick and complete desiccation but dallisgrass and bermudagrasses begin greening up 3 to 4 days after application. Kalmbacher and Martin (1983) used a combination paraquat and burn treatments which was successful. Glyphosate has slower desiccation and is more phytotoxic to the grasses than paraquat. The glyphosate rate which results in good desiccation but does not significantly harm the grass stand is very specific and varies from one grass species to another which leaves little room for error in chemical application.

There is another group of chemicals which are used for postemergence grass control in cotton, soybeans, and peanuts. There primary advantage is that they desiccate the grass but are not phytotoxic to clover seedlings that may be present at the time of chemical application. Fusilade (fluazpfop-P-butyl) and Poast (sethovydim) are examples. They are **NOT** cleared for pastures. Clearance of new herbicides for pasture use in the immediate future is poor because of the present public attitude toward reduced pesticide use.

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Table 1. Annual clover germination response to alternating temperatures representing monthly averages at Angleton, Texas.

Species	Aug. 35/25	Sept. 30/20	Oct. 25/15	Nov. 20/10	Dec. 15/5
	Month and temperature °C				
	- - - - - - - - - -	% germination	- - - - - - - - - - -		
Abon Persian	100	90	90	97	88
Arrowleaf (2)†	11	18	97	100	84
Crimson (3)	70	88	96	90	84
Subterranean (5)	26	88	96	94	82

†Number of cultivars

Table 2. Response of seedling parameters to tube height averaged across clover species and growth stage.

Tube height	Plant height	Leaf number	Nodule number	Plant weight
mm	mm			g
0	100.4 b†	53.9 a	2.93 a	1.28 a
25.4	124.1 a	40.4 b	2.68 b	1.00 b
50.8	121.4 a	23.8 c	2.11 c	0.54 c
76.2	101.0 b	13.7 d	1.39 d	0.29 d
101.6	57.8 c	4.4 e	0.54 e	0.06 e
152.4	6.9 d	0.3 e	0.05 f	0.01 e
LSD 0.05	9.4	4.2	0.18	0.14

† Values within a column followed by the same letter are not significantly at the 0.05 Waller-Duncan Multiple Range Test.

Table 3. Response of seedling parameters to growth stage when tubes were placed on seedlings averaged across clover species and tube height.

Growth stage	Plant height	Leaf number	Nodule number	Plant weight
	mm			g
Cotyledon	74.6 c†	20.1	1.41 b	0.46
Unifoliate	78.1 c	22.5	1.53 b	0.55
First leaf	89.3 b	23.4	1.75 a	0.51
Second leaf	99.7 a	25.0	1.78 a	0.60
LSD 0.05	10.2	NS	0.20	NS

† Values within a column followed by the same letter are not significantly different at 0.05 level Waller-Duncan Multiple Range Test.

ECOPHYSIOLOGY OF WHITE CLOVER IN PERENNIAL PASTURES

C. P. West[1]

INTRODUCTION

White clover (*Trifolium repens* L.) occurs widely across diverse environments of the southern region of the U.S. It is the most important legume in pastures in humid temperate zones world-wide and possesses attributes of ecological significance and economic value. White clover has many agronomic attributes such as perenniality and the ability to spread vegetatively by stolon elongation. It can tolerate heavy, or continuous, grazing and produces forage of a consistently high nutritional quality. White clover has a very high capacity for symbiotic N_2 fixation under favorable growing conditions. However, white clover does have weaknesses which limit its persistence and competitiveness with perennial grasses, such as short stature and poor pest resistance and drought tolerance. I will review aspects of the ecophysiology of white clover that impact its management in pastures. This paper draws heavily from books edited by Baker and Williams (1987) and Marten et al. (1989).

GROWTH HABIT AND MORPHOLOGY

Seedling development is quite distinct from the growth habit of the established plant. After epigeal emergence of the cotyledons, a unifoliolate leaf emerges as the first true leaf, followed by trifoliolate leaves. The mainstem consists of compressed internodes; therefore, the apical growing point remains close to the soil surface and forms a rosette of leaves. A taproot develops and nodules containing *Rhizobium trifolii* form on the taproot and secondary roots. After 5 to 6 leaves have emerged, stolons begin to elongate from axillary buds. The mainstem apex soon stops producing leaves or, occasionally, may differentiate into a stolon itself. The original mainstem and taproot may persist up to 1 to 2 years depending on the environment.

Stolons grow along the soil surface producing nodes and internodes. A node comprises one leaf, two root primordia, of which usually one penetrates the soil, and an axillary bud. Leaves emerge from an apical meristem on tips of stolons or stolon branches. The leaf lamina unfolds as the petiole extends vertically through the canopy. These traits make white clover an effective early invader of disturbed soils or bare areas. The practical significance of the stoloniferous growth habit is that the growing points are usually not removed by defoliation and thus can continue producing leaves while being grazed. Another practical advantage is that the available forage consists only of highly digestible, high protein leaves. The lack of vertical stem elongation, however, restricts the height to which the white clover canopy can develop and therefore limits its ability to compete for light in tall canopies.

The axil of a leaf can produce either a stolon branch or a flower but not both. Production and elongation of stolon branches is an important mechanism for vegetative reproduction and persistence. Once the original mainstem and taproot die, the basic growth unit of white clover consists of a stolon and its branches. Its change in mass is a function of the net balance between senescence at the proximal end and growth at the distal ends.

The original seedling produces an identifiable taproot with secondary thickening and branching; however, within a couple years it usually succumbs to pests or diseases. Enhancing taproot pest resistance is an important means of increasing drought tolerance and improving white clover persistence. Stolons produce adventitious roots from nodes when in contact with moist soil and these roots exhibit little or no secondary thickening (Caradus, 1977). There is,

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however, genetic variation for secondary thickening in nodal roots that may be exploited for improving root longevity (Pederson, 1989).

The ecophysiological significance of nodal root formation is that it allows rapid establishment of independent growth units in colonized soil areas. The tradeoff is that roots tend to be shallow and short-lived, and therefore, the plant must continually invest a major portion of its photoassimilates into synthesis of new stolons, roots and nodules. This is the energy cost of being able to invade and temporarily dominate new soil areas.

ECOLOGY AND ADAPTABILITY

White clover is found in a wide range of environments but is best adapted to moist, cool temperate zones. Its center of origin spans across Eurasia where a great diversity of germplasm exists. Northern types tend to be short-petioled, small-leaved, highly stoloniferous, very winter hardy and tolerant of frequent defoliation. Mediterranean types, on the other hand, tend to be large-leaved, have fewer, thicker stolons and deeper taproots, exhibit winter growth, tolerate infrequent defoliation better, and often behave as a reseeding annual in response to long summer drought. The so-called "Ladino" type of white clover, an ecotype from the Ladino region of Italy fits this category.

White clover can grow in moderately acid soils, but is favored by slightly acid to neutral pHs. White clover also requires a moderate to high soil fertility in terms of phosphorus and potassium to remain competitive with grasses.

Stable populations of white clover exhibit a high degree of genetic variability; but, of even greater ecophysiological significance is the fact that plants within a genotype exhibit a high degree of phenotypic plasticity, that is, the ability to change their morphology in response to defoliation. Under infrequent defoliation, plants become tall, large-leaved and produce few stolons. Under frequent defoliation, plants are short, small-leaved and more densely stoloniferous. This behavior results from an integration of physiological responses to defoliation and changing light conditions, with the consequence that efficiency of energy utilization is maximized for competitive fitness and stand maintenance.

Since white clover growth units are relatively short-lived, stand stability depends on replacement of growth units. A so-called persistence strategy consists of the following traits which either prolong the life of a growth unit or assure its rapid replacement: (1) White clover is opportunistic in that it rapidly exploits open microniches. (2) Its numerous nodal roots and stolon branches allow the plant to exist as independent units and to isolate damaged units. (3) Stolon burial by earthworm castings can offer protection from desiccation or uprooting. (4) Stolon and seed production offer dual means of reproduction, the relative importance of which depends on the environment. (5) Phenotypic plasticity extends the range of conditions under which the plant can remain competitive. (6) Investment of assimilates into stolons assures vegetative reproduction. And finally, (7) white clover integrates environmental responses into a so-called competitive strategy, since it usually grows in competition with other species.

COMPETITIVE INTERACTIONS

White clover has several traits which can be viewed either as weapons in the competitive struggle with companion grasses or as attributes which allow compatibility with a grass. That all depends on whether their niches are overlapping or separated. Rapid attainment of full light interception and stolon spreading into open areas between grass plants constitute spatial niche separation. Differential growth periods, such as cool-season clover growth with a predominantly warm-season grass, is a type of temporal niche separation. Symbiotic N_2 fixation on the part of clover would constitute a sort of nutritional niche separation, which eventually benefits the grass as well.

Horizontal leaf orientation and a high extinction coefficient allow white clover to compete effectively for light at low levels of leaf area index (LAI). At higher LAI, however, grass stem elongation and vertical leaf orientation allow grasses to more effectively intercept light at the top of the canopy. This was demonstrated in the classic paper by Brougham (1958) in which white clover and perennial ryegrass (*Lolium perenne* L.) were grown in monocultures and in mixtures. In monoculture, white clover attained 95% light interception in about 2 weeks at an LAI of only 3.5, with a maximum eventually reaching 5.5. In mixture with ryegrass, 95% light interception occurred at a modestly higher LAI (4.5), but grass leaves continued to elongate above the clover canopy to reach a maximum sward LAI of 7.3. The grass monoculture attained 95% light interception later during the growth period than the clover alone and at twice the LAI.

Low-growing growth habit and horizontal leaf orientation are beneficial to white clover under frequent defoliation (low LAI), but at high LAI, its limited genetic potential for petiole elongation restricts its competitiveness for light and reduces its content in the sward. This is especially important if grass growth has been stimulated with N fertilizer.

Symbiotic N_2 fixation allows white clover to invade and thrive in soil low in available N. The agronomic significance is that N_2 fixation constitutes a cheap means of N input into pastures and initiates a cycling mechanism allowing the transfer of N to an associated grass. However, nitrogen accumulation eventually stimulates grass competitiveness and reduces the clover content of the mixture.

Besides atmospheric sources, white clover can derive combined N from soil organic matter, synthetic fertilizers, animal excreta, and decomposing plant residue. The build-up of mineral N from legume residue and animal excreta exert a feedback inhibition on N_2 fixation, resulting in a long-term steady state under favorable growing conditions. The steady state is characterized by multi-year oscillations in the clover-grass contents based on build-up and depletion of mineral N and perhaps pest population cycles. The net result is that stable white clover-grass mixtures are at a low clover content (10-20%), and in a chronic state of N deficiency. In the lower south of the U.S., steady state conditions are normally not attained because of excessive stress from drought and pests.

The cultivar 'Grasslands Kopu' seems to present an opportunity, at least in New Zealand, of raising the equilibrium clover content level and therefore increase the input of N into a pasture system. In a field trial, Ledgard and Eltilib (1989) showed that Kopu was able to compete better with perennial ryegrass than 'Grasslands Huia', as manifested by a higher Kopu clover content, and to contribute more N to the system through symbiotic fixation. Higher growth rate and competitiveness for light explain Kopu's ability to fix more N_2 than Huia when grown in a N-fertilized mixture with ryegrass (West et al. 1985).

PROSPECTS FOR IMPROVING WHITE CLOVER IN THE SOUTH

Even though it is the main perennial pasture legume in the South, white clover is presented with formidable biotic and abiotic limitations to its persistence. In fact, it is often managed as an annual. The main perennial grasses, tall fescue (*Festuca arundinacea* Schreb.) and bermudagrass [*Cynodon dactylon* (L.) Pers.], are strong competitors. As a cool season grass, tall fescue occupies the same temporal niche. The endophyte (*Acremonium coenophialum*) in tall fescue stimulates fescue competitiveness (Hill et al., 1989), which may further diminish the ability of white clover to persist. I believe that, in the Upper South, improving stolon survival and vegetative reproduction are the best means of enhancing the reliability of white clover in tall fescue stands.

Bermudagrass, being stoloniferous, occupies the same spatial niche as white clover, but their growth periods only overlap in late spring and early summer. White clover is a poor competitor with

bermudagrass for water and its stolons survive summers poorly. Therefore, reseeding ability would be more important as a mechanism for stand stability, although there is potential for enhancing vegetative persistence in high rainfall areas (G.E. Brink, per. comm.).

Currently the most active effort in improving white clover in the South is by the USDA-ARS group at Mississippi State. The plant breeding program aims to improve persistence by enhancing drought and disease resistance as the greatest stresses limiting white clover persistence (G.A. Pederson, per. comm.). Pederson predicts that increasing virus and nematode resistance would improve drought tolerance and persistence by allowing better root growth. The recently released germplasm, Brown Loam Synthetic 2 (Knight et al., 1988), contains genotypes with superior resistance to drought and two types of virus, compared with 'Regal' and 'Tillman'. Stolon stem rot resistance would improve stolon survival, and introducing improved rooting traits would contribute to enhanced drought tolerance.

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ECOPHYSIOLOGY OF TROPICAL LEGUMES IN PERENNIAL PASTURES

C. G. Chambliss[1], M. J. Williams[2], and A. E. Kretschmer, Jr.[3]

The term "ecophysiology" has been taken from European terminology and can be defined as the study of physiological functions of individual organisms in field environments and communities; life history studies of species or ecotypes. The term has been more generally defined as the study of environmental factors in relation to plants (Mueller-Dombois and Ellenberg 1974).

Kretschmer (1989) lists 33 species from 19 tropical legume genera having some forage potential, although seven of those listed were not being used commercially. In this paper we will discuss attributes of some commercially important tropical legumes, especially those that are used in Florida and how these attributes affect persistence and productivity of tropical legumes in perennial pastures.

ANNUAL LEGUMES

One that is commonly used in Florida is aeschynomene, or American jointvetch (_Aeschynomene americana_ L.), (Hodges et al. 1982). It is a summer-growing annual that is usually planted or re-establishes from soil seed reserves in June when the summer rains start. It has an upright growth habit, reaching a height of 3 to 6 feet (90 to 180 cm) if not grazed. It is adapted to the 'flatwoods' soils, areas of nearly level land where the water table is at or near the surface during the rainy season. Forage quality is high with crude protein (CP) averaging 17.5% and _in vitro_ organic matter digestion (IVOMD) 70%. It provides important supplemental feed for grazing animals during mid to late summer when CP and IVOMD of many of the tropical grasses have declined.

Another summer annual legume of minor importance is phasey bean [_Macroptilium lathyroides_ L. (Urb.)] (Pitman et al. 1986). It is an erect growing herbaceous plant reaching 3 to 5 feet (90 to 150 cm) in height at maturity which occasionally exhibits a viney growth habit. Flowers and seedpods are borne on racemes approximately 6 inches (15 cm) long on a peduncle about one foot (30 cm) in length. Its growth period is similar to that of aeschynomene, although it is sometimes referred to as a short-lived perennial. In some years, with a "warm winter" (min. temp. >32°F), it will perennate in south Florida which allows it to begin growth earlier than aeschynomene. Although it is a good seed producer, deer have been observed to eat the green pods and limit natural reseeding.

Common alyceclover [_Alysicarpus vaginalis_ (L.) DC.], in contrast to phasey bean or aeschynomene, is adapted to well-drained sites. It not only provides excellent grazing but is also used as a hay crop. It is planted by some watermelon growers after the watermelons have been harvested in June, making use of residual fertility, and is grown for one harvest only. One of the major problems with this particular legume is its susceptibility to root-knot nematodes (_Meloidogyne_ spp.). After growing in one location for two to three years, nematode populations build up and legume productivity declines. Resistance to _Meloidogyne_ spp. has been found in _Alysicarpus_ germplasm (Taylor et al. 1986) and a new root-knot resistant cultivar, FL-3, has been developed (Baltensperger et al. 1990b). Hairy indigo (_Indigofera hirsuta_ L.) is also adapted to well-drained soils (Baltensperger et al. 1985). In fact, it is probably better adapted to dry, upland sites than any other legume that is used in Florida. This legume, like aeschynomene, provides a source of protein during the summer and into the fall.

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Unlike aeschynomene, cattle are reluctant to graze hairy indigo when first introduced into a stand, but after a few days they learn to graze it. It is a good seed producer, producing large quantities of hard seed. Baltensperger et al. (1990a) indicates that on average common hairy indigo produces 50% hard seed, which makes it a problem weed in some situations. 'Flamingo', a soft-seeded cultivar, has been released for use in situations where the hard-seeded characteristic of common hairy indigo is undesirable (Baltensperger et al. 1990a).

PERENNIAL LEGUMES

'Florida' carpon desmodium [Desmodium heterocarpon (L.) DC], a native of Asia and the Pacific islands, is being used to some extent by ranchers in south Florida (Kretschmer et al. 1979). A heavy seed producer, it is also a true perennial. Crown buds close to the soil surface allow it to withstand heavy grazing. Reported low digestibility of this selection is thought to be related to high tannin levels, but animal acceptance in grazing studies has been good. Inconsistent establishment has been a problem. Susceptibility to root-knot nematodes may limit the usefulness of this legume on excessively drained soils in Florida.

'Siratro' [Macroptilium atropurpureum (D.C.) Urb.], is a perennial legume grown in many areas of the world, especially Australia, that was introduced into Florida (Kretschmer 1972). It is a deep-rooted perennial with trailing or creeping stems and is relatively tolerant of freezing temperatures (Bogdan 1977). Gramshaw et al. (1989) indicated that commercial adoption in Australia is below expectations and, where planted, persistence has often been poor. The major factor contributing to stand failure is probably reluctance of cattlemen to maintain a light stocking or to use strategic rest periods that would allow the stand to regenerate. It has not been adopted by ranchers in Florida. Similar to the Australian experience, it has not persisted well, largely due to excessively heavy grazing.

Leucaena [Leucaena leucocephala (Lam.) DeWit] is a legume that is being evaluated in Florida (Othman et al. 1985). Selections of this species have been used throughout the tropics for forage, biomass, and green manure production. It is a tall growing, shrubby or arboreal legume adapted to well-drained soils of moderate to high pH. It contains the non-protein amino acid mimosine. Its breakdown product, 3,4-DHP, adversely affects the health of ruminants that graze more than limited quantities of leucaena. Bacteria have been isolated that detoxify this compound when inoculated into the rumen and the health problems are prevented (Hammond et al. 1989).

Tropical kudzu [Pueraria phaseoloides (Roxb.) Benth.] is grown to some extent in South America and other tropical countries. It is a persistent, robust, climbing or trailing perennial with the stems usually covered with rusty-brown hairs (Bogdan 1977). It requires high temperatures for optimum growth and can be killed by frosts. It is adapted to the humid tropics [50+ inches (1200+ mm) of annual rainfall]. It will grow on acid soils with a pH of 4.0 to 5.5. Forage yields are usually higher than kudzuvine [P. lobata (Willd.) Ohwi] that grows in the southeastern USA. Bogdan (1977), said ".....whenever the climatic conditions permit, P. phaseoloides is preferred to P. lobata, the herbage of which is often of lower quality".

The genus Stylosanthes has about 25 species that can be found in the Americas, Africa, and Asia. Townsville stylo (Stylosanthes humilis H.B.K.), an annual, and stylo [Stylosanthes guianensis (Aubl.) SW], a perennial, are native to Central and South America. Both, along with other species of Stylosanthes, have been introduced into Australia. At one time, Townsville stylo was grown over a large area in northern Australia. Since the early 1970's, both S. humilis and S. guianesis have been devastated by anthracnose (Colletotrichum gloeosporoides) (Gramshaw 1989).

The species now used commercially are S. hamata and S. scabra. Growers are using mixtures of S. hamata cv. Verano and S. scabra cv. Seca, both of which possess moderate to high levels of field resistance (Irwin 1989).

Stylosanthes spp. require high light intensity for good growth, and shading by tall grasses is detrimental. S. guianensis can grow under a wide range of temperatures and is more tolerant to cool weather, including frost, than many other cultivated tropical legumes (Bogdan 1977). Even though anthracnose has eliminated the use of S. guianensis in Australia, it may have some potential in south Florida where the disease has not caused a problem. Dr. John Brolmann, with the University of Florida, is developing a cultivar of S. guianensis that will be adapted to south Florida, USA.

The genus Arachis, native to South America, contains about 60 species. Several have potential as perennial forages. Arachis pintoi, a stoloniferous, seed-producing species, is being studied by CIAT (Centro Internacional of Agricultura Tropical) for possible use in Columbia, South America (Asakawa and Ramirez 1989). A cultivar 'Amarillo' from this species was released in Australia in 1987. It can be planted by seed or vegetatively. Selections of rhizomatous perennial peanut (Arachis glabrata Benth.) have been evaluated for forage potential for many years in Florida, USA.

The cultivars 'Florigraze' and 'Arbrook' were released by the Florida Agricultural Experiment Stations and SCS in the 1980s (Prine et al. 1981, 1986). These cultivars form a dense mat of underground stems or rhizomes. Rhizomes are used to propagate these cultivars as they produce essentially no seed. Stand establishment, at the present recommended planting rate, may require two to three years. Drought during the first three months after planting has caused establishment failure. These factors have slowed adoption by cattlemen. Rhizomatous perennial peanut has proved to be adapted to well-drained soils in Florida and Southern Georgia but not to sites that flood or maintain a high water table for an extended time. Stoloniferous types are thought to hold more potential for those sites.

ENVIRONMENTAL AND MANAGEMENT FACTORS AFFECTING TROPICAL LEGUMES

Many of the environmental and management factors affecting tropical legumes have been studied in terms of how they affect persistence. Recently an international conference was held to discuss this problem (Marten et al. eds. 1989). Kretschmer (1988) listed several factors that affect the persistence of legumes (Table 1). Some of these factors are environmental, others are inherent to the particular legume species or cultivar being considered, and others relate to management.

Tropical legumes generally persist and are productive at soil pHs that are lower than what most temperate legume species tolerate. A notable exception is leucaena which does not persist under strongly acid conditions (i.e., below about 5.0), yet grows well in neutral and alkaline soils (Kretschmer 1988). Kretschmer (1988) states "the largest number of tropical legume cultivars presently in use, however, are adaptable to soils with pH above about 5.0, but may grow more vigorously at soil pHs of about 6.5".

In the tropics low soil fertility, particularly phosphorus, can limit legume growth. Overall, the need for K fertilizer is less than that for P, but growth responses to K can be found on the lighter textured soils (Kretschmer 1988).

Most tropical legumes will persist with annual rainfall above 42 inches (1000 mm) in moderately drained soils. A few will tolerate water-logging, aeschynomene being a good example. Under low annual rainfall, the distribution and consistency of rainfall affects legume growth and persistence. Annuals survive and persist as well or better in regions

where annual rainfall of 20 to 30 inches (500-700 mm) occurs in a 3 to 4 month period, than where the average annual rainfall is 30 to 40 inches (750-1000 mm) but unreliable and poorly distributed (Kretschmer 1985).

Relative growth of some legumes, such as tropical kudzu and aeschynomene, is greatly affected by rainfall. As the rainfall increases above 20 to 40 inches (500-1000 mm) per year, the relative growth of these legumes is increased. Deep rooted legumes such as siratro and leucaena are less dependant on high rainfall. In general, leucaena is less sensitive to droughts than siratro, and siratro is less sensitive than tropical kudzu (Kretschmer 1988).

A number of plant pathogens and insect pests may affect some of the tropical legumes but are beyond the scope of this paper. The tropical legumes that have achieved some success in Florida are not seriously affected by pests other than certain species of nematodes.

In a mixed sward, attributes of the associated grass(es) may have a positive or negative effect on the growth and persistence of the legume. Competition for light, nutrients, and space influence legume growth and persistence. A bunch grass with low height and without stolons or rhizomes, may be less competitive than a tall grass, a sod-forming grass such as bahiagrass (<u>Paspalum notatum</u> Flugge), or a grass that has stolons and rhizomes such as common bermudagrass [<u>Cynodon dactylon</u> (L.) Pers.]. Competition for sunlight has a great affect on many legumes. Townsville stylo, a sun-loving legume, grows better when the companion grass is low growing or maintained at a low height. In contrast, a twining, climbing type of legume such as tropical kudzu may grow quite well in competition with such tall-growing grasses as elephantgrass (<u>Pennistetum purpureum</u> Schumach) and guineagrass (<u>Panicum maximum</u> Jacq.).

<u>Table 1. Some of the factors affecting tropical legume persistence.</u>

<u>Soils</u>:
acidity
fertility
texture
drainage

<u>Legume Attributes</u>:
annual - perennial
acceptability
quality - antiquality
(seed production, stolons, rhizomes)

<u>Rainfall</u>:
quantity
distribution

<u>Legume Growth Habit</u>:
prostrate
erect
vine
crown or bud area height

<u>Grass Competition</u>:
bunch
stolons
rhizomes
height
sunlight
nutrients

<u>Grazing Management/Grazing Behavior</u>:
continuous
rotational
grazing pressure
trampling
preferential grazing
combinations of the above

<u>Pests</u>:
diseases
insects
nematodes

Source: Kretschmer 1988 (modified).

Certain attributes of a particular legume may contribute to its ability to persist. As previously mentioned, legumes with a viney type of growth habit may climb tall grass to reach the sunlight. Legumes that have a crown or buds low on the stem, such as carpon desmodium, may be more tolerant of overgrazing than other types. A legume that has only moderate acceptability to grazing animals may be more persistent than one that is highly acceptable. High seed production and high seed stores in the soil may help perennial legumes to persist if the original plants are destroyed. Re-establishment can occur from seed that were produced in previous seasons (Keating and Mott 1987).

The effect of grazing or various grazing management strategies on tropical legumes has been studied by several researchers (Jones and Harrison 1980; Hodgkinson and Williams 1983; Sollenberger and Quesenberry 1985, 1986; Jones and Clements 1987; Sollenberger et al. 1987; Jones and Bunch 1988; Pitman et al. 1988; Aiken 1989; Ortega 1990; Chaparro et al. 1991).

Ortega (1990) studied the response of rhizoma perennial peanut to grazing stress. During the establishment phase of two to three years, this legume lays down a mat of rhizomes 2 to 3 inches (50-76 mm) thick just below the soil surface. This large source of plant reserves helps the plant survive periods of stress whether from overgrazing, drought, or insect damage. Ortega evaluated the effect of combinations of post-graze residual dry matter of 450, 1340, 2230 pounds per acre (500, 1500, and 2500 kg/hectare) and length of grazing cycle, (7, 21, 42, and 63 days) on peanut herbage accumulation, rhizome mass, and rhyzome total non-structural carbohydrates (TNC). He found that large declines occurred in these variables by the end of two grazing seasons for the 450 lb residual dry matter treatments only. Additionally, at that level of residual dry matter, very marked increases in peanut performance were observed with increasing length of grazing cycle. Even when marked changes in botanical composition occurred, total herbage accumulation did not show an effect of experimental treatment. This was due to a substiution effect; as peanut content decreased, common bermudagrass increased. His conclusions were: "Residual dry matter was the most important experimental variable influencing most responses measured. For both years, ...rhizome mass and rhizome TNC increased at a decreasing rate as residual dry matter increased".

Seed production, soil moisture, and shading are critical factors in maintaining annual legumes in a sward from year to year. The effect of these factors on the establishment of aeschynomene on sandy soils has been studied by several researchers (Kalmbacher and Martin 1983; Sollenberger and Quesenberry 1986; Sollenberger et al. 1987; Kalmbacher et al. 1988; Chaparro et al. 1991a).

Kalmbacher et al. (1988) found that bahiagrass sods disked or grazed to a three-inch height (76 mm) allowed 60% of sunlight to reach aeschynomene seedlings during the first four weeks after seeding. Without controlling canopy height, an average of 36% of the total sunlight penetrated the grass leaf cover. Soil moisture may be a more serious problem. Kalmbacher et al. (1988) concluded that "the greatest reason for stand failure of aeschynomene is inadequate soil moisture at, or shortly after, seeding (germination). The problem occurs when there is adequate moisture for germination but not enough soil moisture to carry the legume plant from one shower to the next". Chaparro et al. (1991a) concluded that "long-term persistence of stands will be difficult to achieve where rains during establishment period are unpredictable".

Tropical legumes vary considerably in their reaction to environmental and management factors. One common problem with many of the legumes is that of persistence. It is expected that researchers will continue studying these potentially valuable plants in order to find ways to overcome the problems that limit their commercial adoption.

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NUTRITIONAL PRINCIPLES INVOLVED IN SUPPLEMENTING GRAZING CATTLE

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Ruminants infrequently achieve their genetic potential for production even when grazing cool season, temperate forages; forages which are of the highest nutritive potential of the grasses. This limitation is illustrated in figure 1 which summarizes results of a four year stocking rate study with calves grazing ryegrass and ryegrass-clover mixtures at Angleton Texas (Riewe, unpublished).

Note that season long rate of gain increased progressively as stocking rate was reduced on both ryegrass and ryegrass-clover. Extrapolation of this relationship between gain and stocking rate to the most nutritionally luxuriant stocking rate suggests that maximum season long gains from either pasture was less than 1.0 kg/day; less than the genetic potential of these medium framed calves.

The season long gains indicated in figure 1 are also than expected based on the nutrient content of such forage. Typically, ingested ryegrass from annual ryegrass pastures will contain a minimum of 15 % crude protein and 70 % digestible organic matter (Ellis et al. 1983), concentrations which should not be nutritionally limiting in terms of dietary nutrient concentrations within dried or preserved feedstuffs (National Research Council, 1984).

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Results in figure 1 also demonstrate superior gains by calves grazing ryegrass-clover mixed pastures as compared to ryegrass alone. Such improved productivity from legume-grass mixtures is consistent with their greater content of crude protein (Beever et al. 1983) and true protein flowing to the intestines.

RUMINANT PROTEIN NUTRITION

Nutrition studies have consistently indicated wide variations by the ruminant in efficiency of digestive/metabolic utilization of dietary nutrients from different feedstuffs. In order to equate nutrients required in the diet with nutrient requirements at the tissue level, a comprehensive system is needed to quantitatively integrate ruminant digestive and metabolic transformations of dietary nutrients to nutrient supply to the tissue. A number of such proposed systems have been reviewed by a subcommittee of the National Research Council and a more comprehensive quantitative system has been proposed for describing nitrogen usage (N.R.C., 1985). This system is being implemented in revised National Research Council publications concerning nutrient requirements of dairy cattle.

A major advancement in the NRC system of feedstuff nitrogen evaluation is the separate partitioning of nutrient requirements by animal tissues from the nutrient requirements by ruminal microbes. These seperate requirements must be simultaneously considered with the nutrient content of feedstuffs to predict feed-digestion-metabolic interactions. Nutrient requirements by the animal's tissues is

estimated based on the composition of expected gains and expected efficiencies involved in transforming nutrient supply to nutrient usage. Nutrient requirement by ruminal microbes is estimated based on the fact that ruminally fermented energy limits their growth rate and hence establishes their requirement for intake protein which is degraded in the rumen. The importance of these separate expressions will be illustrated by reference to figure 2.

Protein available to support the animal's tissue requirements is derived from two sources; intake protein escaping the rumen which is digested (DUP) and digested microbial protein (DBP). The quantity of digestible undegraded intake protein (DUP) provided by the diet is a function of dietary protein intake and the extent that such dietary protein is undegraded in the rumen and escapes to the intestines. When the diet is adequate in ruminally degraded intake protein (DIP) and other essential nutrients for rumen microbes, the quantity of rumen microbial protein synthesized is a function of the quantity of energy derived from microbial digestion of carbohydrates, primarily cell wall substances of forages.

Because energy flux to the rumen microbes is the rate limiting process, ruminally degraded intake protein (DIP) in excess of the energy limiting microbial requirement for DIP is converted to urea and largely excreted in the urine. The flow nature of figure 2 emphasizes the need to synchronize the flow of DIP with the flow of energy being digested in the rumen in order to most efficiently utilize DIP and maximize digestion of cell wall fiber.

Based on the NRC system, approximately 15 g of DIP are required for each 100 g of digestible organic matter intake (DOMI) from all forage diets. Thus in forages of 60 % organic matter digestibility (OMD), DIP in excess of 9 % would be digested as urea and be largely nonnutritious. Limitation in usage of DIP is of paramount nutritional significance because proteins of growing forages appear to be extensively (> 80 %) degraded in the rumen. Thus a freshly grazed forage containing 16 % crude protein and 60 OMD would provide a DIP supply of 12.8 % (16 % X .8). This level of crude protein considerably exceeds the DIP requirement (9 %) while providing only small amounts of DUP (16 % x .2 x .9 digestible or 2.9 % DUP).

REQUIREMENTS FOR SUPPLEMENTAL NUTRIENTS

Information required for determining supplements appropriate for foraging animals are summarized in table 1.

Using the NRC Nitrogen Usage System and other data allows a comparison of nutrient requirements by the animal with nutrient supply from forage alone. Figure 3 compares nutrient requirements for a 200 kg calf to gain 1 kg/day to nutrient supply from 5 kg of grazed, actively growing coastal bermudagrass pasture. Typically, such bermudagrass will contain 60 % OMD and 14 % crude protein of which .80 or 11.2 % is DIP and only 2.5 % is DUP (14 x .2 x .9 digestible).

TABLE 1. INFORMATION REQUIRED FOR FORMULATING SUPPLEMENTS FOR FORAGING RUMINANTS

1. REQUIREMENTS (animal)
   - A) RUMEN MICROBES- Ruminal flux of energy
   - B) ANIMAL TISSUES- Animal's genotype
2. SUPPLY (forage)
   - A) NUTRIENT CONTENT OF FORAGE
     1) DUP
     2) DIP
     3) Nutritive energy
   - B) FORAGE INTAKE
3. INTERACTIONS (forage-supplement)
   - A) SUPPLEMENTARY, NUTRITIONAL
   - B) SUBSTITUTIVE, NON-NUTRITIONAL

The results in figure 3 indicate that the bermudagrass is excessive (120 %) in DIP, only 36 % adequate in DUP and only 60 % adequate in available protein (AP) derived from the digestion of DUP and DIP. Thus, grazed coastal bermuda is first limiting in AP, a deficiency which would limit gains to considerably less than 1 kg/day.

Correction of the AP deficiency requires supplements which either 1) reduced the excessive ruminal degradation of forage proteins to DIP, 2) increased efficiency of conversion of DIP to microbial protein and/or 3) provide supplementary DUP.

Currently, there are few options to reduce wasteful degradation of the high protein content of grazed forages or improve conversion of DIP to microbial protein. Ionophores have a small effect on reducing ruminal degradation of protein and low levels of starch and sugars may be stimulatory to microbial synthesis.

ASSOCIATIVE EFFECTS OF MIXTURES OF FEEDS

Associative effects of feeds occur when the nutritive potential of two feeds are greater than or less than the sum of the two feeds fed alone. Associative effects may be due to nutritive and non-nutritive effects.

Associative nutritive effects occur due to supplementary effects of two feeds being better balanced in their nutritive content than the individual feeds fed alone. For example, feeding a mixture of a proteinaceous feedstuff with a protein deficient forage will reduce a deficiency of DIP and thereby increase growth rate of rumen microbes, digestibility of fiber and intake of the forage. In such cases, increased forage intake is the result of both increased fiber digestion (and consequent flow of digested energy) and increased flow of microbial protein (and consequent increased flow of AP providing an improved nutritional protein status at the tissue level), (figure 2). Thus, this associative effect is the result of associative nutritive effects at both the digestive and metabolic levels. Evidence as in figure 4 indicates than levels of approximately 7 % crude protein in forage dry matter are required to maximize digestibility of forage fiber and forage intake.

Conceptually, associative nutritive effects are related to nutritional imbalances of any kind and will not exist in "nutritionally balanced"

diets. Associative nutritive effects are most evident in ruminant diets and reflect the intricate, interventive and interactive role of rumen microbes between nutrient intake and nutrient supply to the tissues. The interventative role of ruminant digestion necessitates the separate identification of nutritive requirements of rumen microbes from those of the animals' tissues (figure 2).

Associative nutritive effects of feeds in ruminants are commonly due to deficiencies of ptotein, phosphorus, cobalt, or, in certain circumstances, energy. Associative nutritive effects due to dietary energy source may occur due to stimulating effects on rumen microbial growth and/or improvements in tissue nutrient status such as a protein sparing effect. Like other associative nutritive effects, these effects are most pronounced when the primary feedstuffs, usually forage, is of low nutritive value. Such associative effects involve both digestive and metabolic responses. Typically, beneficial responses are limited to relatively low levels of highly digestible sources of energy, such as starch or sugars, which are stimulatory to microbial growth. The tissue effect may be a consequence of altered composition of volatile fatty acid production and /or flow of digested carbohydrate to the tissue in sparing protein metabolism and/or increased flow of digested microbial protein (see figure 2).

Based on data of Egan (1977), voluntary intake of forage may not be maximized until levels of intestinally, truely absorbed protein (AP) exceeds 20% of digested organic matter (figure 9). This data illustrates the limiting effect on forage of a deficiency intak of protein relative to energy in the absorbed end products available for tissue metabolism.

Because associative nutritive effects are the result of nutritional deficiencies or imbalances, they can be effectively capitalized on in forage supplementation programs. For example, a small amount of supplemental feed mixture may provide the limiting nutrients to materially improve the digestive or metabolic efficiency of utilization of the major feedstuff, forage. Thus, improved animal productivity per unit of supplement provided will be considerably greater than simply the nutrients provided by the supplement.

NON-NUTRITIVE, NEGATIVE ASSOCIATIVE EFFECTS

Typically, nutritive associative effects of feed mixtures are positive effects. Negative associative effects occur when the productivity of a mixture of two feedstuffs is less than expected based on the nutritive content of each feed individually. The most common example is the negative effect of feeding combinations of grain and fibrous feedstuffs. This is illustrated by typical data (Torres and Boelcke, 1976) in figure 5.

As indicated in figure 6, increasing levels of grain in a forage based ration may not result in the expected increases in digestibility of mixed ration's dry matter. This lack of an additative effect is the consequence of increasing levels of grain progressively depressing digestibility of ration cell wall substances; substances predominantly supplied by the forage (figure 7).

Although depressing forage digestibility, low levels of grain (< 20-30 %) may increase intake of total dry matter (figure 8) and total digestible dry matter (figure 9). In terms of flow of nutrients portrayed in figure 2, additions of grain depresses digestion of fiber by diverting fermentative yield of digestible energy required for microbial growth from more slowly fermentable fiber to more rapidly fermentable cell contents (starch). The greater yield of fermentable energy from grain supported increases growth rate of rumen microbes and consequent increases flow of AP to the animal's tissues.

Because the forages in figures 6-95-8 were adequate in crude protein, increased feed intake was probably the result of improvements in the animals' protein nutrition status at the tissue level. Nutritional status was probably improved as a consequence of increased flow of AP from microbial protein together with sparing effects on tissue protein catabolism associated with increased supply of gluconeogenic materials in the form of propionate (from altered VFA production) and glucose (derived from digestion of grain starch escaping ruminal degradation).

The negative associative effects of grain on forage fiber utilization is commonly attributed to an effect of pH upon rumen microbial ecology. It is thought that ruminal digestion of the more rapidly fermenting starch results in more rapid and altered VFA production rates which lowers pH and thereby depresses growth of fiber digesting microbes (Mould, 1988).

SUBSTITUTIVE EFFECTS OF SUPPLEMENTS ON FORAGE UTILIZATION

The time spent grazing and ruminating occupies a considerable amount of the grazing animals lifetime. Further, ruminants graze as social units (herds). To the extent that supplementation may compete with available grazingrumination time or alter grazing patterns, supplementation may simply substitute for nutrients which would otherwise be derived from grazed forage.

SUPPLEMENTS FOR GRAZING CALVES

Responses to protein supplementation was assessed in four different trials conducted by the Texas Agricultural Experiment Station. Growing calves grazed bermuda grass or sorghum-sudan hybrid pastures and receiving either a feed supplement or a free choice mineral mixture. As compared to the mineral supplement, average daily gain was significantly increased by all protein supplements (figure 10). However, supplements containing fishmeal resulted in significantly greater gains than for cattle receiving cottonseed meal or cottonseed meal and urea as the primary source of protein. In contrast to fish meal, greater levels of supplemental crude protein from cottonseed meal (>.6 to .8 lb/head/day) failed to further stimulate gains. This failure reflects its high levels of DIP and low content of DUP of cottonseed meal compared to fishmeal.

The results with fishmeal clearly indicate a large potential for increasing gains from warm season pastures such as coastal bermudagrass by supplements of DUP. To effectively use such expensive sources of DUP, their intake must be limited to maximize supplementary effects and avoid substitutive effects.

An estimate of supplemental efficiency can be obtained if it is assumed that the supplement does not substitute for forage consumption, i.e., the increased gain of protein supplemented calves was derived from more efficient digestion/metabolism of the forage-supplement mixture. In the current studies, supplemental efficiency was expressed as lb of supplement per lb of increased gain by the protein supplemented over the calves receiving mineral only. The relationship between supplemental efficiency and level of supplement is summarized in figure 11.

Supplemental efficiency decreased (more supplement/lb of increased gain) as level of self-fed supplement increased. Corn consumed at a daily level of 3.5 lb./head required over 9 lb to produce a lb. of gain; a less efficient utilization than would be expected had the corn been properly supplemented and fed in confinement. The greater efficiencies of fishmeal supplements could be attributed to their greater supply of DUP and possible better amino acid balance in improving metabolic utilization of AP.

Collectively, the results in figure 11 indicate the need to restrict daily supplement intake to less than 2 lb per head by such 550 lb, medium to large frame calves in order to maximize supplementary effects and minimize substitutive effects.

IMPLICATIONS

Considerable evidence indicates that amino acid deficiencies at the ruminant's tissue level limit protein growth in growing cattle grazing growing forage. This tissue deficiency appears particularly acute in animals grazing grass pastures because of the extensive degradation and wasteful digestion of proteins in fresh, green forage. Systems of computing the protein requirements of ruminants in terms of their different digestive routes identifies more specific forms of dietary protein which are first limiting and hence required in supplements. Responses to date suggests the potential exists for doubling gains by growing calves grazing warm season, semi-tropical with approximately one lb/ head of a properly formulated protein supplement.

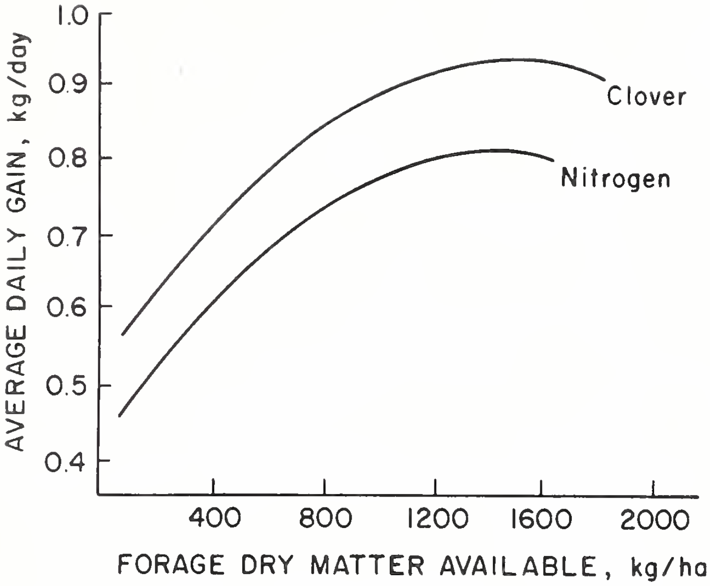


Figure 1. Season long calf gains as influenced by stocking rate on ryegrass and ryegrass-clover pastures (Courtesy of M.E. Riewe, Texas Agricultural Experiment Station at Angleton).

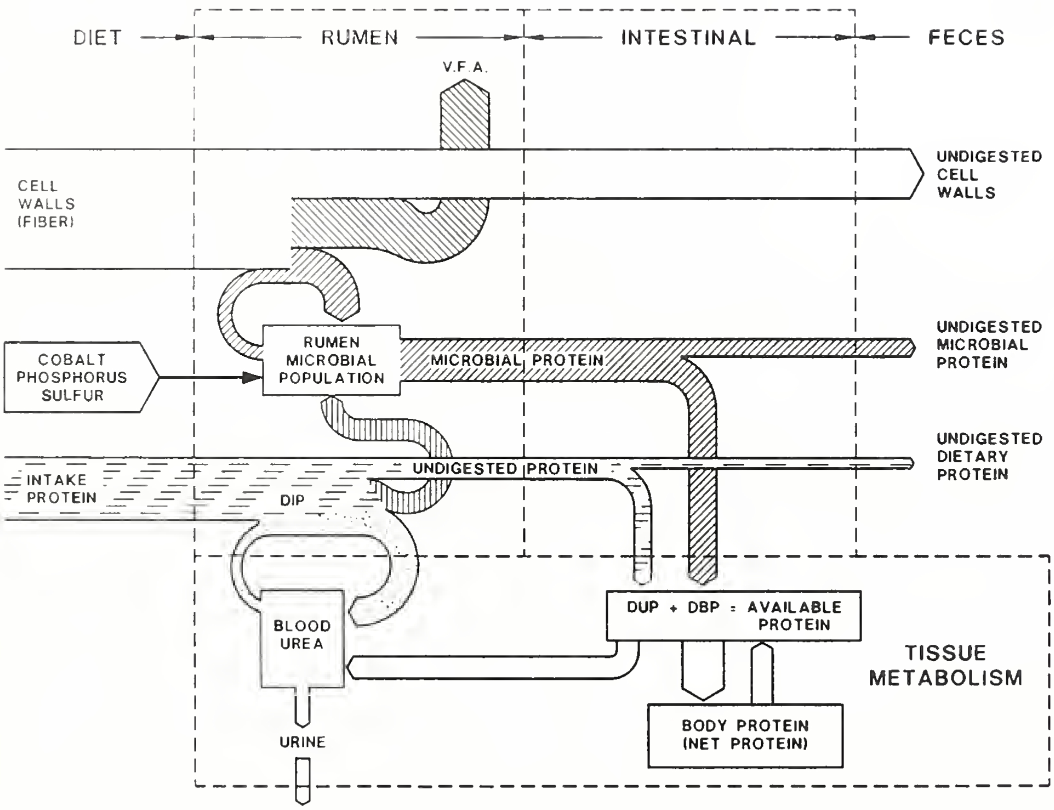


Figure 2. The interrelated flow of digestive and metabolic transforming processes in the ruminant and the interventive role of microbial digestion.

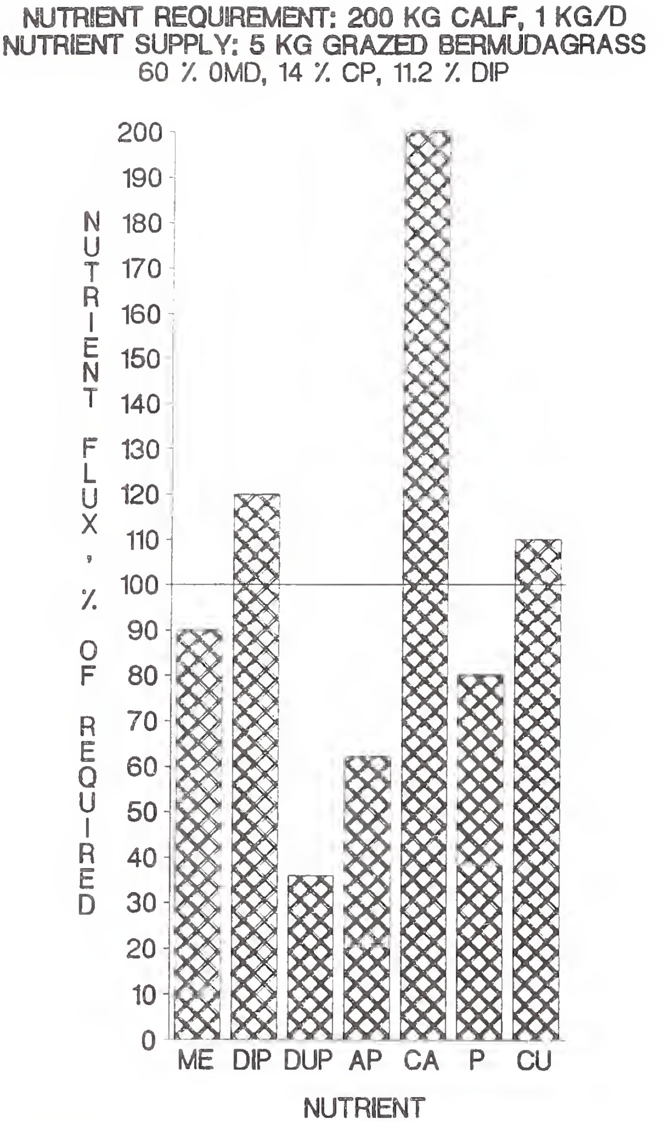


Figure 3. Nutrient flux from grazed bermudagrass versus nutrient requirement of a 200 kg grazing calf (according to NRC, 1985).

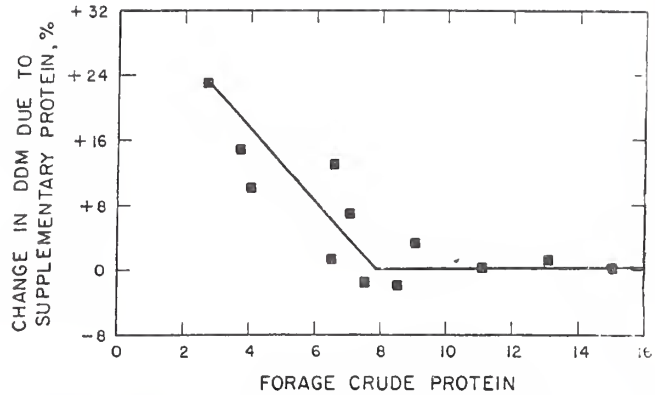


Figure 4. Effects of crude protein content on digestibility of forage dry matter (W. C. Ellis, unpublished).

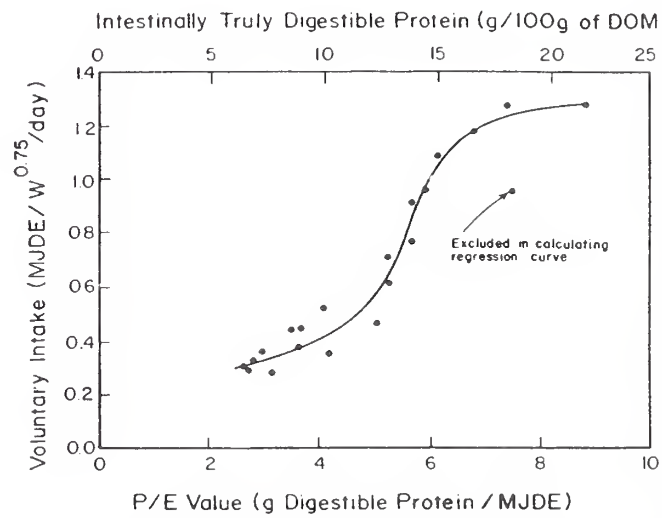


Figure 5. Relation between voluntary intake of forage by lambs and protein energy value of absorbed nutrients (Modified from data of Egan, 1977).

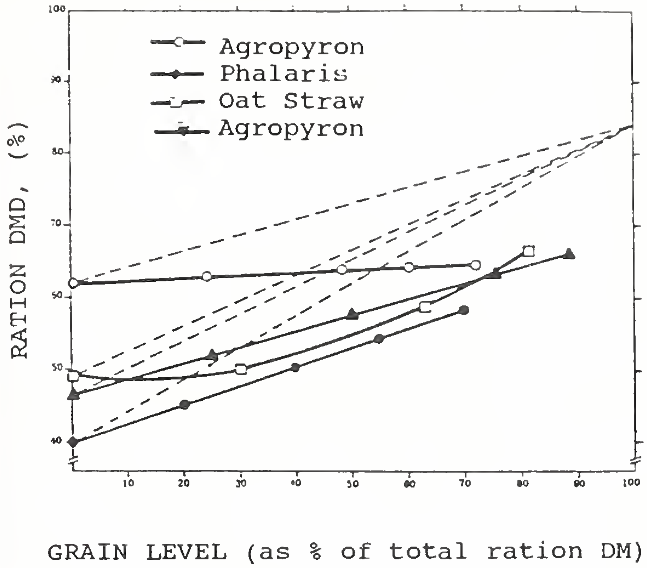


Figure 6. Associative effect of grain level on digestibility of forage grain mixtures (expected as sum of grain and forage, ---------) observed (————————). (Torres and Boelcke, 1976).

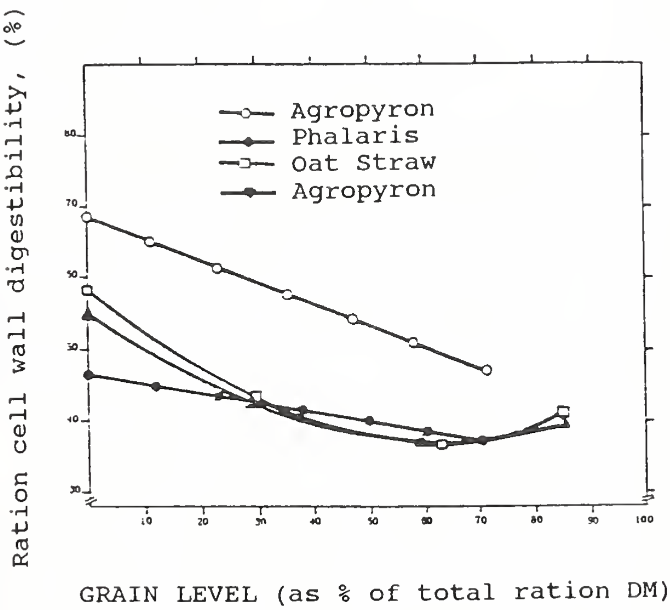


Figure 7. Effects of grain level on digestibility of cell wall constituents. (Torres and Boelcke, 1976).

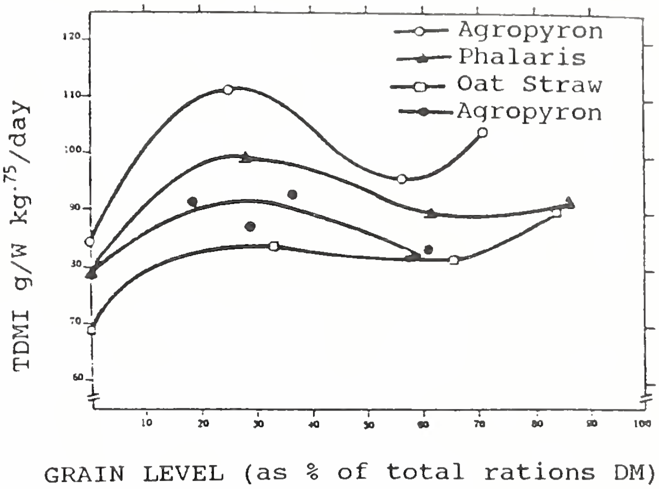


Figure 8. Effect of grain level on intake of forage-grain mixtures. (Torres and Boelcke, 1976).

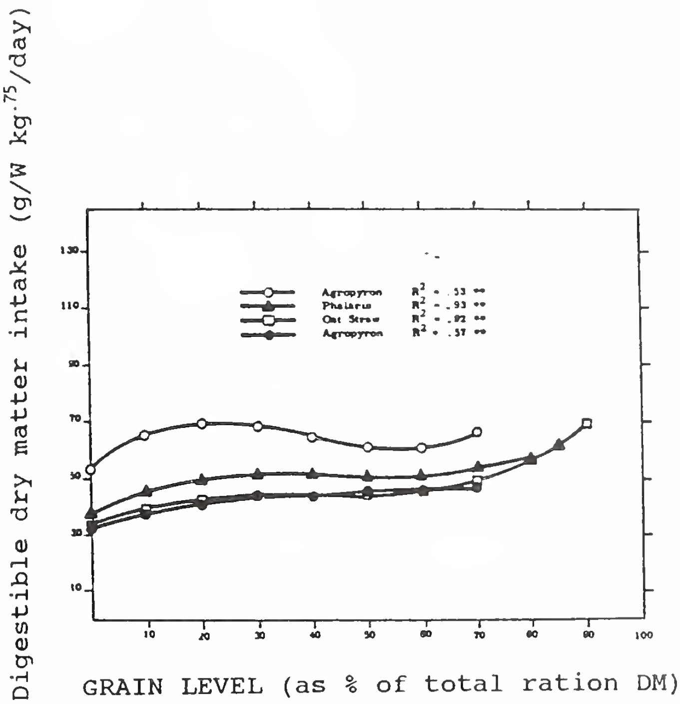


Figure 9. Effect of grain level on intake of digestible dry matter from forage-grain mixtures. (Torres and Boelcke, 1976).

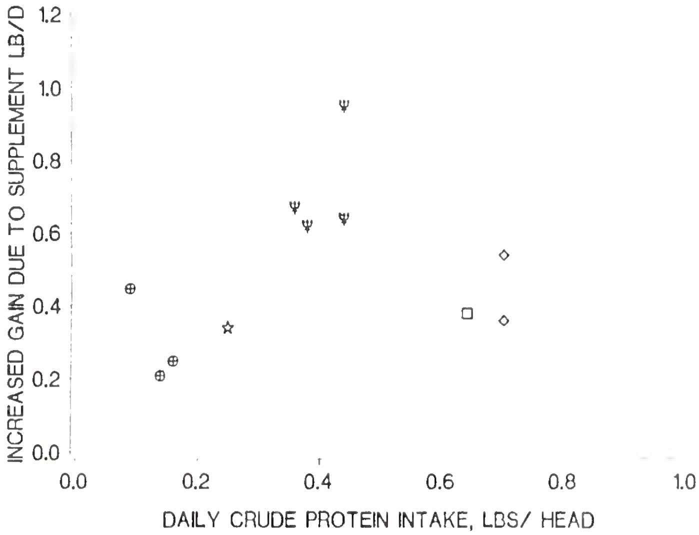
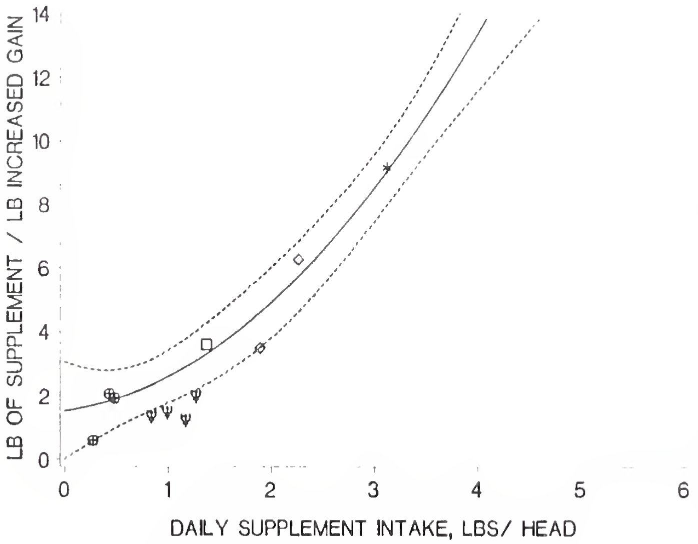


Figure 10. Increased gain due to supplemental source of nutrients for calves grazing warm season pastures (⊕ - molasses - protein block, ★ - corn, spears - fish, square - cottonseed meal, ♦ - cottonseed and urea).



SOURCE OF DATA: TEXAS AGRICULTURAL EXPERIMENT STATION

Figure 11. Efficiency of use of different supplemental sources of nutrients by calves grazing warm season pastures (⊕ - molasses - protein block, ★ -corn, spears - fish, square - cottonseed meal, ♦ - cottonseed and urea).

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ENERGY AND PROTEIN SUPPLEMENTATION OF GROWING CATTLE ON WHEAT PASTURE

Gerald W. Horn

INTRODUCTION

Winter wheat pasture is a very unique and economically important renewable resource in Oklahoma and the southern Great Plains. Income is derived from both grain and the increased value that is added, as weight gain, to growing cattle that are grazed on wheat pasture. The potential for profit from grazing stocker cattle on wheat pasture is exceptionally good because of the high quality of the forage and the very favorable seasonality of prices for stocker and feeder cattle which favor price appreciation of the cattle.

Supplementation of cattle grazing wheat pasture is of interest in order to provide a more balanced nutrient supply and feed additives such as ionophores and bloat preventive compounds. One of the watch words of the cattle industry today is predictability. Predicting performance of wheat pasture stocker cattle is particularly challenging because of the potentially large variation in weather and amounts of available forage. If cattle performance cannot be predicted, breakeven selling prices cannot be calculated and strategies for managing market risk become more uncertain. The ability to predict cattle performance will become more important as the feedlot and stocker segments of the industry compete for supplies of stocker/feeder cattle and as different segments of the stocker industry compete for stocker cattle.

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ENERGY SUPPLEMENTATION

Both the digestibility of DM and the crude protein (CP) content of wheat forage are high. Wheat forage will commonly contain 75% digestible DM and 25 to 30% CP during the fall and early spring grazing periods. Because of this very high CP content, traditional thinking has been that supplemental energy would be beneficial. Hogan and Weston (1970) and Hogan (1982) emphasized the importance of providing a balanced supply of N and digestible OM for effective capture of degraded N by rumen microorganisms. Beever and Siddons (1986) and Beever et al. (1987) further emphasized the importance of the balance of degraded N and degraded OM supply in ruminants fed fresh forages. Hogan (1982) related ruminal ammonia concentrations and amounts of N entering the small intestine per unit of N intake to forage DOM:CP ratio. At ratios less than 3:1 ruminal ammonia concentrations increased sharply and net losses of N were observed at ratios less than about 4:1. For perspective, the DOM:CP ratio of wheat forage containing 75% digestible OM and 25% CP is 3:1. Accordingly, supplemental energy should improve the balance between N and energy supply from wheat forage in the rumen.

Silage can be used to "stretch" available wheat forage and(or) allow initial stocking densities on wheat pasture to be increased. In studies reported by Vogel et al. (1987, 1989), use of supplemental silage allowed initial stocking density on wheat pasture to be doubled without decreasing weight gains of stocker cattle. Supplemental silage decreased wheat forage intake linearly ($P<.10$). Each pound of added silage DM decreased DM intake of wheat forage by .66 lb. Extent of ruminal digestion of DM and NDF of wheat forage was increased by feeding silage indicating that silage had a positive associative effect on utilization of wheat forage (Vogel et al., 1989).

Results of several studies relative to feeding grain or grain-based energy

supplements to growing cattle grazing small grain pastures are summarized in Table 1. Elder (1967) reported results of a 3-year study where ground corn or milo was fed ad libitum to steers on rye and wheat pasture. Average grain consumption of the steers (450 lb initial weight) was 5.5 lb/head/day. It was noted that daily consumption "varied greatly from month to month"; and that, although "good forage was always available for grazing", steers ate 10 lb of grain daily during some of the winter months. Steer daily gains, grazing days per acre and total beef production per acre were increased .34 lb (25%), 39 days (21%) and 131 lb (51%), respectively. Mean efficiency of grain utilization, calculated on an acre basis, was 9.4 lb per pound of increased gain per acre.

Gulbransen (1976) fed dry rolled milo ad libitum to steers on oat pastures with six stocking densities that ranged from 1 to .2 acres/head. Carcass gain per acre was linearly related to grain consumption per acre and increased by .097 lb for each lb of grain dry matter consumed. Efficiency of grain utilization, was therefore 10.3 lb (1/.097) which is similar to 9.4 reported by Elder (1967). In studies conducted by Lowrey et al. (1976a and 1976b), daily "grain" consumption of steer calves and yearlings fed grain ad libitum on rye, wheat and ryegrass mixed pastures was about 1.1 percent of their body weight. In these studies stocking density was doubled and daily gains of the cattle fed grain were increased only .12 lb. Extensive studies, relative to feeding grain to steers on small grain pasture, have been conducted at the Tifton, Georgia Station by Utley and McCormick (1975 and 1976). Consumption of corn dry matter by yearling steers fed dry or high-moisture ensiled whole shelled corn ad libitum on oat pastures was about 1.2 percent of body weight per day (Utley and McCormick, 1975). Consumption of grain by yearling steers fed whole shelled corn or rolled milo ad libitum on rye pastures was about 1.5 percent of their body weight per day (Utley and McCormick, 1976). Daily gains of steers and stocking density on rye pastures were increased about .64 lb and doubled, respectively, where grain was fed (Utley and McCormick, 1976). In the studies of Utley and McCormick much larger weight gain responses were observed and stocking density was increased much greater than in the studies of Elder (1967).

Where moderate to high levels of grain were fed in the above studies, supplement conversion (expressed as lb/lb of increased gain <u>per acre</u>) ranged from 6.7 to 10.3 (Table 1), stocking density was increased by 21 to 100% and increases in gain were highly variable (i.e., range of + .11 to .65 lb/day). This large variation makes it difficult to evaluate the economics of energy supplementation of growing cattle on small grain pastures, and the predominant sources and coefficients of variation should be identified in future studies.

Three studies with low levels of energy supplementation are summarized at the bottom of Table 1. The supplement conversion of 1.84 reported by Grigsby et al. (1988) is comparatively very low. The underlying mechanism for this low conversion should be identified.

Results of a recently conducted study by Horn et al. (1990) are shown in Table 2. Fall-weaned steer calves grazed clean-tilled wheat pasture and received no supplement other than free-choice access to a commercial mineral mixture or were hand-fed 6 days/week a corn-based energy supplement (i.e., high-starch supplement) or a high-fiber energy supplement that contained about 47% soybean hulls and 46% wheat middlings (as-fed basis). A fourth treatment was fed the high-fiber energy supplement ad libitum. All of the energy supplements contained monensin (about 40 mg/lb) and the ad libitum fed supplement contained 8% salt. Stocking density on wheat pasture was increased 33% (i.e., from 2 to 1.5 acres/steer) where the energy supplements were fed. Supplements were fed for 96 days of the 115-day trial. Target level of consumption was .75% of mean body weight. Weight gains were

increased (P<.02) by supplementation (i.e., control versus mean of all supplements) and by the high-fiber versus the high-starch supplement (P<.02). Gains were not influenced (P>.09) by method of feeding the high-fiber energy supplement. Conversion of supplements, (expressed as lb/lb of increased gain per acre) ranged from 4.88 to 6.70 and was substantially lower than reported by Elder (1967). Conversion of supplement was improved (P<.05) by the high-fiber versus high-starch supplement and by hand-feeding versus ad libitum feeding the high-fiber supplement. An explanation for the difference in method of feeding the high-fiber supplement is not apparent, but may be related to the greater variation in daily intake of the free-choice (3.13 to 8.72 lb) versus hand-fed (3.0 to 5.0 lb) supplement and potential effects on rumen function and forage intake.

PROTEIN SUPPLEMENTATION

The National Wheat Pasture Symposium was held in Stillwater in the fall of 1983 to summarize the data base relative to production and utilization of wheat pasture by cattle. Beever (1984) presented data that was interpreted to suggest that performance of rapidly growing cattle on wheat pasture may be limited by flow of inadequate amounts of non-ammonia N (NAN) to the small intestine. Johnson et al. (1974) reported CP values of wheat forage of 25 to 31% of DM during January to April with 17 to 33% of the nitrogen (N) being in the form of non-protein nitrogen (NPN). Horn et al. (1977) observed total soluble N and soluble NPN concentrations of wheat forage of 45 to 62 and 25 to 37% of total N, respectively. Beever et al. (1976), in studying different conservation methods for perennial ryegrass, observed a significant negative relationship (r = -.98, P<.001) between the amount of N flowing into the small intestine (grams per 100 g N consumed) and solubility of forage N in .01% pepsin in .1N HCl. Egan (1974), Ulyatt and Egan (1979) and Egan and Ulyatt (1980) reported large losses (i.e., 40 to 45%) of ingested N from the rumen of sheep fed high-protein ryegrass. Studies by Vogel et al. (1989) have shown that N of immature and mature wheat forage exist kinetically as two distinct pools with different rates of in situ ruminal disappearance. Approximately 50 to 75% of total forage N disappeared from a "very rapid disappearance" pool at rates of 16 to 19% per hour. Broderick (1984) also suggested the presence of two "degradation fractions" of N of alfalfa hay. MacRae and Ulyatt (1974) reported that 63% of the variation in live weight gain of sheep grazing ryegrass or white clover pasture was associated with the amount of NAN absorbed from the small intestine, and that there was no relationship between live weight gain and energy absorbed as volatile fatty acids (i.e., a measure of the "energy status" of the animals). These data indicated that the traditional concept that performance of growing cattle on wheat pasture is not limited by protein status should be reevaluated.

For the past few years a major portion of my research has been directed toward characterizing nutrient digestion and supply in cattle grazing wheat pasture and determining the effect of additional supplemental protein of low ruminal degradability (i.e., escape protein) on stocker cattle performance. Studies have been conducted over four wheat pasture years to determine the effect of feeding additional escape protein on weight gains of stocker cattle grazing wheat pasture. Details of the studies have been reported by Vogel et al. (1989) and Smith et al. (1989). The trial in year 1 (1985-86) was conducted in cooperation with Panhandle State University (Goodwell, Oklahoma); the remaining trials were conducted at the Forage and Livestock Research Laboratory (USDA/ARS, El Reno, Oklahoma). About eighty fall-weaned beef calves were used each year. Mean initial weight of the cattle ranged from 477 to 513 lb and the trials were 92 (12/8 to 3/10) to 125 days (11/14 to 3/19) in length. Each year the cattle were randomly allotted by weight within breed groups to four treatments in a randomized complete block design with

two replications. Cattle of Treatment 1 received no supplement (other than free-choice access to a commercial mineral mixture) while those of Treatments 2, 3 and 4 were fed daily 2 lb of a corn-based energy supplement or supplements that provided about .25 kg of protein from high-escape protein as cottonseed meal produced by mechanical extraction, meat meal, meat and bone meal or corn gluten meal. The .25 kg of protein from high-escape protein is very similar to the levels used by Anderson et al. (1988) in which supplemental escape protein increased gains of steers grazing smooth brome pastures. The supplements were isocaloric and contained similar amounts of calcium, phosphorus and magnesium. Monensin was included in the supplements to supply 130 to 150 mg/head/day.

Results of the first three trials are shown in Table 3. Mean consumption of the energy, meat meal and cottonseed meal supplements were 1.76, 1.58 and 1.78 lb DM/day. Cattle completely consumed the supplements in year 1 up until March 4 at which time consumption decreased because of increasing amounts of available forage. In years 2 and 3, the meat meal (or meat and bone meal) content of the supplements was increased from 16.6% to about 23.5% (as-fed) in order to increase the amount of protein provided by the supplements. This decreased consumption of these supplements. Mean consumption of the energy, meat meal (or meat and bone meal) and cottonseed meal supplements was 1.63, 1.52 and 1.65 lb DM/day (year 2) and 1.69, 1.36 and 1.78 lb DM/day (year 3).

Daily gains of the cattle were increased ($P<.03$) about .22 lb by the overall effect of supplementation. The meat meal, meat and bone meal or cottonseed meal supplements did not increase ($P>.30$) gains as compared with the corn-based energy supplement. Calculated supplement conversions were 11.4, 7.2 and 6.2 lb of supplement per lb of increased gain for cattle fed the energy, meat meal or cottonseed meal supplements, respectively. Differences among supplements were not significant. Conversion of the energy supplement was similar to that of 9.4 and 10.3 reported by Elder (1967) and Gulbransen (1976).

Results of the fourth trial are shown in Table 4. Consumption of the supplements was good and it was never necessary to measure any refusals. Daily gains of the cattle were increased ($P<.03$) about .30 lb by the overall effect of supplementation. The cottonseed meal or corn gluten meal supplements did not increase ($P>.50$) gains as compared with the corn-based supplement, nor did source of supplemental protein influence gains. These results are very similar to those of the first three trials. Ruminal degradability of feedstuffs varies with type of diet and level of feed intake (Zinn and Owens, 1983; Goetsch and Owens, 1985). We (Vogel et al., 1988; Vogel, 1988) characterized ruminal N degradation of several high protein feedstuffs in cattle grazing wheat pasture. Ruminal N degradation of cottonseed meal produced by the mechanical process was 49% and was less than 66% for cottonseed meal produced by direct solvent extraction. Ruminal degradabilities of meat and bone meal and meat meal were 44 and 52%, respectively.

Calculated supplement conversions in Trial 4 were 7.3, 5.5 and 8.0 lb of supplement (as-fed) per lb of increased gain for cattle fed the energy, cottonseed meal and corn gluten meal supplements, respectively. Differences among supplement conversions were not significant ($P>.45$).

Lee (1985) reported that weight gains of calves grazing wheat pasture and fed 1.5 lb/day of a supplement containing 15% meat meal were increased .20 lb/day as compared with a control, hominy feed-based supplement. Anderson et al (1987) reported a similar gain response by stocker cattle grazing wheat pasture fed 1.50 lb/day of a supplement that contained 11.5% feather meal and 19.4% meat and bone meal. Our studies are not in agreement with these studies. Differences in amounts of available wheat forage, the number of days of snow and(or) ice cover and the amounts of other supplemental feeds that were fed

may account for part of the discrepancy of results. In the study of Anderson et al. (1987), cattle had free-choice access to wheat hay throughout the 79 days of grazing wheat pasture and free-choice access to corn silage during 21 days of the trial when snow cover "inhibited grazing". This fairly high level of supplementation with wheat hay and corn silage would favor a response to additional supplemental protein.

Anderson et al. (1988) reported significant improvements in weight gains of growing cattle grazing brome pastures from supplemental protein provided as a mixture of corn gluten meal and bloodmeal. As shown in Table 5, their pastures contained substantially less total protein and less escape protein than wheat forage of our studies. These differences may have resulted in differences in the amount of escape protein reaching the small intestine. Also, because of big differences in potential intake of fermentable OM, the potential for ruminal microbial protein synthesis would be much greater for cattle grazing wheat pasture. Estimated microbial plus escape CP is 581 and 727 g/day for brome and wheat pasture, respectively, as shown in Table 5. These values, represent 79 and 99% of the requirement of 735 g for a 200 kg medium-frame steer gaining .80 kg/day (NRC, 1985). Differences among forages with regard to their potential intake of fermentable OM and rumen microbial protein synthesis should be considered, in addition to characterizing ruminal degradability of forage protein, in evaluating the potential benefit of supplemental escape protein.

In our studies ruminal escape protein was provided from single sources of protein as cottonseed meal, meat meal, meat and bone meal or corn gluten meal (CGM). Meat meal and meat and bone meal are good sources of lysine. Corn gluten meal is high in sulphur-containing amino acids but is sometimes criticized as a source of escape protein because of its low lysine content. Because of the very high content of lysine in blood meal, the combination of blood meal and CGM used by Anderson et al. (1988) would compliment each other with respect to amounts of lysine and the sulphur-containing amino acids. In the study of Irlbeck et al. (1989) yearling steers grazing brome pasture were supplemented with increasing amounts of escape protein from either CGM or a CGM/blood meal mixture. Escape protein improved gain, but there was no difference between CGM and CGM/blood meal as sources of escape protein.

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Table 1. Response of growing beef cattle to grain supplementation on small grain pastures.

Reference	Forage	Stocking density, steers/acre Control	Stocking density, steers/acre Grain	Grain consumption % of body wt.	Daily gain of steers, lb Control	Daily gain of steers, lb Grain	F/G[a]	F/G[b]
				Moderate to high level of supplementation				
Elder, 1967	Rye and wheat mix		+21%	1	1.38	1.72	9.4	
Gulbransen, 1976	Oat	...............Variable[c].............			2.44		10.3	
Utley & McCormick, 1976	Rye	.77	1.49	1.5	2.33	2.98	7.2	
Lowrey et al., 1976A	Rye, wheat, ryegrass mix	1.01	2.02	1.2	1.98	2.09	7.0	
Lowrey et al., 1976B	Rye, wheat, ryegrass mix	1.01	2.02	1.1	2.20	2.33	6.7	
				Low level of supplementation				
Grigsby et al., 1988	Rye, ryegrass mix	------ XXX[d] ------		0.2 (1.16 lb)	2.22	2.85		1.84
Vogel et al., 1989	Wheat	------ XXX -------		0.30 (1.76 lb)	1.78	1.93		11.4
Smith et al., 1989	Wheat	------ XXX -------		0.32 (2.00 lb)	2.42	2.69		7.3

[a]Grain conversion, lb/lb of increased gain per acre.
[b]Supplement conversion, lb/lb of increased gain.
[c]Regression study.
[d]Stocking density was not increased because of low level of energy supplement that was fed.

Table 2. Effect of type of energy supplement and method of feeding on performance of steers grazing wheat pasture[a].

Treatment: Method of Feeding:	Control	High-starch Hand-fed	High-fiber Hand-fed	High-fiber Free-choice	Contrasts: Control vs Supplementation	Contrasts: High-starch vs High-fiber	Contrasts: Method of feeding high-fiber supplement
Number of steers	48[b]	48	48	48			
Stocking density, acres/head	2	1.5	1.5	1.5			
Supplement consumption[c], lb/day[d]	---	4.20	4.27	5.09			
% of body wt		.71	.72	.85			
Initial wt,(11/17) lb	464	464	463	466			
Final wt,(3/12) lb	710	716	732	725			
Daily gain,(115 days) lb	2.14	2.19	2.35	2.25	P<.02	P<.02	NS, P>.09
Supplement conversion[e]	---	5.94	4.88	6.70		P<.05	P<.05

[a]Horn et al. (1990). Unpublished data.
[b]Four replicates of 12 steers/replicate per treatment.
[c]Control steers had free-choice access to a commercial mineral supplement.
[d]Supplements were fed 96 days of the 115-day trial.
[e]Lb of supplement (as-fed) per lb of increased gain per acre.

Table 3. Effect of protein supplementation on performance of growing steers on wheat pasture (Trials 1-3).

	Treatment				
	Control	Corn	Meat Meal[a]	Cottonseed Meal[b]	SE
Number of cattle	52	52	52	51	
Supplement consumption, lb DM/head/day		1.76	1.58	1.78	.07
Initial weight, lb	474	476	483	479	2.5
Final weight[c], lb	667	684	697	703	8.4
Daily gain[c], lb	1.78	1.93	1.99	2.06	.07
Supplement conversion[d]		11.4	7.2	6.2	4.5

[a]Meat and bone meal in trial 3.
[b]Produced by mechanical extraction.
[c]No supplement vs supplementation ($P<.05$).
[d]Lb of supplement per lb of increased weight gain.

Table 4. Effect of protein supplementation on performance of growing steers on wheat pasture (Trial 4).

	Supplement				
	Control	Energy	Cottonseed meal[a]	Corn gluten meal	SE
Number of cattle	20	20	20	20	
Supplement consumption, lb/head/day	0	2	2	2	
Initial weight, lb	503	497	501	504	13.5
Final weight, lb	726	745	758	755	15.0
Daily gain (92 days), lb	2.42[b]	2.69	2.79	2.72	.06
Supplement conversion[c]		7.3	5.5	8.0	1.88

[a]Produced by mechanical extraction.
[b]No supplement vs supplementation ($P<.03$).
[c]Lb of supplement (as-fed) per lb of increased gain. Differences among treatments are not significant ($P>.45$).

Table 5. Comparison of calculated escape protein and microbial CP production from brome and wheat forage versus requirement of a 200 kg growing steer.

	Smooth brome (Anderson et al., 1988)[a]	Wheat forage (Vogel, 1988)[b]
CP, %	11.9(15)	(24)
IVDMD, %	56-60	70-84
Soluble carbohydrate, %		22-41
Rate of ruminal protein degradation, %/h	12-14	16-18
Rate of passage, %/h	5	4.6
Estimated escape protein, %	9-13 Kp/(Kp + Kd)	30
Escape protein per kg forage DM consumed, g	20 (1x.15x.13)	72 (1x.24x.30)
Estimated forage DM intake, % of body wt.	2.4	2.8
Microbial CP synthesis, g/day	561[c]	655[c]
Microbial + escape CP		
g/day	581	727
% of requirement	79[d]	99[d]

[a]J. Anim. Sci. 1988. 66:237.

[b]Ph.D. Thesis. 1988. Oklahoma State University.

[c]200 g Microbial CP per kg of OM apparently digested in the rumen. From: ARC. 1984. The Nutrient Requirements of Ruminant Livestock (Supplement No. 1). Agricultural Research Council. England.

[d]Percentage of requirement (i.e., 735 g) of a 200 kg medium-frame steer gaining 0.8 kg/day. From: NRC. 1985. Ruminant Nitrogen Usage.

SUPPLEMENTATION OF CATTLE ON RANGELAND

Keith S. Lusby

ABSTRACT

Well designed supplementation programs can greatly enhance utilization of native forages. Protein supplementation of stockers grazing tallgrass range during summer can maintain good gains throughout the summer. Energy supplements formulated with adequate protein can improve performance in situations where protein alone is not adequate. Ingredients low in starch but high in digestible fiber may be the best sources of supplemental energy for native forages.

INTRODUCTION

Millions of cattle graze native rangelands in the United States. Because native grasses tend to follow consistent seasonal patterns for nutrient content, needs for supplementation can be quite accurately predicted within given areas of the country and types of native forages. Optimizing forage utilization should be the goal of any supplementation program. The economics of a supplementation program will depend on the effect the supplement has on forage utilization.

A tremendous amount of literature has been compiled on the subject of supplementation of range forages over the past 50 years. The tendency for the author to use data from his home station should not be interpreted as meaning that other work is less important but only that using familiar work saves time in manuscript preparation.

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REASONS FOR FEEDING SUPPLEMENTS ON RANGELAND

There are many reasons for feeding supplements to cattle that are grazing or being fed forage diets. Some reasons are more common than others and the advent of new feed additives such as the ionophores have added more reasons for considering whether a supplement could improve the profitability of a cattle venture. A list of reasons for feeding supplements will contain many of the following:

1. Correct some deficiency in the diet. This is the most common reason for feeding supplements. Common deficiencies include protein and phosphorus in most of the country and can include other mineral and vitamin deficiencies in certain parts of the country during certain times of the year.

2. Increase carrying capacity or stretching forage supplies. During times of drought, supplements may be needed to meet some of the energy needs of cattle.

3. Provide a carrier for growth promotives. Some marginally economical supplementation programs may be profitable if a growth promotive agent is added.

4. Aid in preventing or treating certain health problems. Examples are the use of supplements as carriers for poloxolene to control bloat in cattle grazing legume or small grains pastures, as carriers for coccidiostats, or as carriers for chlortetracycline in areas where anaplasmosis is a problem.

5. Enhancing cattle management. Small amounts of supplements can be used to aid in checking or gathering cattle. Cattle accustomed to being fed even a small amount of supplement will come to a truck horn and can be gathered or moved to new pastures with minimal labor.

PROTEIN SUPPLEMENTS

Summer Supplements

Supplementation with protein supplements of stockers grazing tallgrass range from mid to late summer usually results in efficient conversions of supplement to added gain. The most common ingredients in protein supplements are the oilseed meals--soybean meal, cottonseed meal, sunflower meal, linseed meal, and other high protein sources such as corn gluten meal and meat meal. Factors such as forage quality, quantity, animal size and age, desired level of production and relative value of cattle and cost of feed must be carefully considered.

Protein is the first limiting nutrient in many range forages. Inadequate protein reduces intake and digestibility resulting in depressed performance. Typical seasonal declines in quality of tallgrass forage as measured by CP, ADF and NDF content are shown in Table 1. Samples in this study were obtained from esophageally fistulated steers (Campbell and McCollum, 1988) and probably contain higher levels of CP than hand clipped samples. According to NRC (1984), steers weighing 500 lbs and gaining 1.5 lb/day require at least 10.5% crude protein in the diet. Based on these samples, the forage would be deficient in early June.

The positive effect of protein on forage intake is well demonstrated in a New Mexico study (McCollum and Galyean, 1985) in which steers fed prairie hay were fed either no supplemental protein or 1.75 lb of cottonseed meal. Feeding supplemental cottonseed meal decreased the time required for passage of the hay through the rumen by 32 percent and increased hay intake by 27 percent (Table 2).

A number of studies with stockers grazing native range in various sites in Oklahoma have shown that feeding one pound of high protein supplement from July to mid-October can efficiently increase gains of summer stockers (Lusby et al., 1982; Lusby and Horn, 1983; Lusby et al., 1984; Gill et al., 1984; McCollum et al., 1985; Cantrell et al., 1985; Fleck et al., 1987).

Results shown in Table 3 are typical of the several studies listed. The cattle used in the study (Lusby et al., 1982) were yearling steers grazing native pastures from mid-July to mid-October. The cattle were fed either a soybean meal supplement at the rate of .8 lb or 1.5 lb/day, or 3 lb of corn supplement. Gains were improved in all groups receiving supplements although conversions of supplement to added gain were more efficient with the high protein supplement. The 8.8 lb of 10 percent protein grain supplement required per pound of added gain is consistent with many experiments. It is likely that 3 lb/day of grain reduced the intake and/or digestibility of the forage to some degree.

One additional point needs to be made about the study shown in Table 3. All the supplements were prorated for feeding on Mondays, Wednesdays and Fridays. There is ample evidence that high protein supplements can be fed every two or three days with no effect on the efficiency of the supplement. Cattle apparently are very capable of recycling nitrogen within their bodies. On the other hand, feeding large amounts of high grain supplements can reduce forage utilization (Chase and Hibberd, 1987). Grain supplements are probably most efficiently utilized when fed on a daily basis so that the amount of supplement at a single feeding is kept to a minimum. The good conversions of pounds of protein supplements to added gain are evidence that forage intake was increased because it is not reasonable to assume that soybean meal fed alone could produce gain at an efficiency of under 3 lb of feed per pound of added gain.

There is evidence that light calves (under 400 lbs) may respond to supplemental protein earlier in the summer than will yearlings. This is logical because protein requirements are higher for younger cattle. In a recent study (McCollum and Lusby, 1989), 375 lb calves fed 1 lb/day of 38% protein supplement

from May 23 to June 21 showed significantly improved gains over controls that were fed no supplement. Conversion of supplement to added gain was 2.2:1. A similar response was observed for the following period from June 21 to July 19. During the same study, calves fed isonitrogenous supplements containing 15 or 25% CP had supplement to added gain conversions of 8.2 to 10.5:1. Similar findings were reported by Scott et al., (1987).

Cattle grazing shortgrass range forages may not respond to summer protein supplements to the degree seen for tallgrass forages (Stanton and Shoop, 1989, Table 4). Although CP content was apparently similar to estimates given for Oklahoma tallgrass forages during the same period, gains were not improved by feeding 2 lbs/day of 40% CP supplement. Control gains were above 2 lb/day indicating that protein content of the forage was not deficient. In Oklahoma studies in which gains were improved with protein supplements, daily gains for unsupplemented controls were typically much lower than 2 lbs/day. Forage CP during the study ranged only from 5-9% which would appear too low to account for the high daily gain achieved. Forage in the Colorado study was sampled by hand clipping which may have yielded samples lower in CP than samples from esophageal fistulas. In the several Oklahoma studies cited, gain responses to added protein supplements were not seen when gains of unsupplemented controls exceeded 1.5 lb/day.

ENERGY SUPPLEMENTS

There are limits to the improvements in performance that can be attained on low to medium quality forages with protein supplements alone. Drought and overstocking also create forage shortages in which there is insufficient forage to consider the use of protein supplements. Energy requirements of young cattle or lactating cattle may exceed the energy intake obtainable from a given forage, even with a reasonable amount of protein supplement. In these cases, additional energy must be supplied either in the form of greater amounts of grain-based supplements or by changing the cattle to a higher quality forage. Total energy intake can be increased by feeding grain-based supplement to cattle consuming a forage diet. However, the pounds of energy supplement that is fed may not yield as large an improvement in performance as might be expected. The reason lies in the effect that grains have on forage intake and digestibility. While relatively small additions of high protein feeds to a protein deficient forage diet can increase forage digestibility and intake, additions of grain supplements may not have the same effect. Grain supplements may only slightly increase forage intake and quite often may actually decrease forage intake, especially if daily amounts of grain are large.

The high starch content of grains accounts for the depression in forage intake and digestibility that is frequently seen. Starch is rapidly fermented in the rumen. Apparently, the rumen bacteria will preferentially attack the readily fermentable starch before they begin to digest the less digestible fibrous components of forages. This is not entirely a new concept. Hamilton, (1942) and Swift et al., (1947) reported that glucose addition reduced cellulose digestion in roughage diets of ruminants. Fontenot et al., (1955) found that addition of protein mitigated the negative effects of sugar on cellulose digestion. Fontenot et al., (1955) concluded "Thus, it appears that in wintering rations the value of additional energy in the form of readily-available carbohydrate is nullified, in part, by the decreased digestibility of protein and crude fiber."

A good illustration of the relationship between forage quality and type of supplement is shown in two Nebraska trials (Clanton and Zimmerman, 1970). The studies (Table 5) evaluated gains of replacement heifers being wintered on Nebraska winter range and fed supplements that varied in protein and energy content. In Trial 1, increasing supplemental energy did not improve gains at the low (.3 lb)

protein level. Increasing energy when .6 lb of protein was fed gave slight increases in gain. In Trial 2, increased energy improved gains when .8 lb of protein was fed but actually reduced gains when .4 lb of protein was fed. These studies show that protein must be simultaneously increased when energy is increased in order for the extra energy to be utilized in agreement with Fontenot et al., (1955).

Feeding relatively large daily quantities of grains with low protein forage may reduce total energy intake by decreasing forage intake and/or forage digestibility. The Nebraska workers showed this when they fed 2 lb of the 20 percent protein supplement and 5 lb of the 8 percent supplement to calves in drylot receiving a 9 percent protein grass hay. Calves fed the 20 percent protein supplement gained .81 lb per day and ate 10.6 lb of hay while calves fed the 8 percent supplement gained .9 lb per day but ate only 8.2 lb of hay.

The Nebraska studies point out two facts. First, protein must be balanced with energy. If the forage is protein deficient, protein must be simultaneously added along with supplemental energy. Second, while performance can be increased by supplementing low to medium quality forages with grain supplements, the increased gain is seldom efficiently achieved.

More recent Nebraska trials (Anderson et al., 1988) demonstrate the difficulty in efficiently translating the high energy content of grains to added gain in grazing cattle. The Nebraska workers compared gains of stockers grazing fall bromegrass pasture or fall-winter cornstalks when the stockers were supplemented with 3 lb/day of rolled corn versus 3 lb of whole soybean hulls (Table 6). Corn is a high starch grain while soyhulls are a highly digestible fiber source. Gains of steers grazing the fall bromegrass pastures were excellent (2.29 lb per day without supplement). Feeding 3 lb of supplemental corn increased gains by .22 lb per day while feeding 3 lb of soyhulls increased gains by .3 lb per day. The conversion of either supplement to added gain was poor (10:1 for soyhulls and 13.6:1 for corn). Gain responses with heifers grazing cornstalks were similar to those seen with the steers grazing bromegrass.

The fact that soyhulls, which are higher in fiber content than corn, produced a greater increase in gain than corn suggests that feeds with a high proportion of their energy in the form of digestible fiber rather than starch may be better energy sources for grazing cattle than grains. Studies by Fleck et al., (1987) showed that corn gluten feed, a byproduct feed high in digestible fiber and low in starch was an effective source of supplemental energy for cows grazing dormant native range in winter and yearling heifers grazing native range in summer. Studies with wheat middlings (16% CP, 33% starch, 8% ADF) showed that wintering performance of cows grazing native range was similar when cows were supplemented with wheat middlings or equal amounts of a 16% CP supplement formulated from corn and soybean meal (Cox et al., 1989).

Sanson et al., (1990) found that digestibility of low quality (4.3% CP prairie hay was decreased when the level of supplemental corn increased from .26% to .52% of body weight. Cows grazing native range lost more weight when supplemented with soybean meal and corn than when supplemented with soybean meal alone. They suggested that addition of corn to supplements for cattle grazing low quality roughages be done carefully to avoid depression of digestibility and intake. In a similar study, Sanson and Clanton, (1989) reported that supplemental corn at levels above .25% of body weight reduced intake of grass hay (5.2% CP) while corn above .20% of body weight reduced intake of higher quality (7.0% CP) hay.

The more efficient conversions of supplement to added gain seen with high protein supplements compared to high grain supplements do not automatically mean that protein supplements are always the most economically efficient. Economic efficiency will depend on the relative cost of grains and protein sources. However, if the conversion of supplement to added gain can be predicted, the most cost efficient supplement can be chosen. One must also consider the impact of supplements on stocking rate. The forage sparing effect of grains can sometimes be beneficial and must be considered in the economic analysis.

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Table 1. Diet Components From Esophageally Fistulated Steers Grazing Tallgrass Range in North Central Oklahoma.

	Sample Date					
	Mid May	Early June	Late June	Mid Aug	Early Sept	Late Sept
CP	12.2	9.9	8.5	7.6	7.8	7.5
ADF	42.9	45.8	43.8	44.9	47.0	47.6
NDF	76.2	78.3	78.6	81.2	81.2	74.4

Table 2. Effects of Cottonseed Meal on Rate of Digestion and Intake of Prairie Hay by Steers.

	No Cottonseed Meal	1.75 lb Cottonseed Meal	Change
Rumen retention time, hours	74.9	56.5	-32%
Hay intake, % of body weight	1.69	2.15	+27%

Table 3. Weight Gains of Steers Grazed on Native Range During Late Summer and Fed Protein or Energy Supplements.

	Treatments[a]			
	Control No Supp.	.8 lb 39% Supp.	1.5 lb 43% Supp.	3.0 lb 10% Supp.
Number of steers per group	21	21	21	20
Initial weight, 7/16/81, lb	578	576	578	590
Daily gain, lb:				
7/16/81 to 9/04/81	1.76	1.94	2.40	1.81
9/04/81 to 10/20/81	1.09	1.83	1.50	1.71
Total period, 96 days	1.44	1.88	1.97	1.78
Lb Supp/lb added gain	--	1.8	2.8	8.8

[a]Percentages refer to the percent protein in each supplement.

Table 4. Daily Gain of Heifers Grazed on Buffalo Grass-Blue Gramma Forage in Eastern Colorado.

	Supplement Treatments			
	Control	Protein	Protein + Rumensin	Protein + Bovatec
Initial wt 7/15	603	606	602	608
Daily gain 103 days	2.12	2.28	2.25	2.22

Table 5. Daily Supplements and Gains of Heifers on Native Range, Fort Robinson, Nebraska.

Trial 1	.3 lb Supplement Crude Protein/Day				.6 lb Supplement Crude Protein/Day			
Supp/day, lb	0	1.5	3.0	4.5	0	1.5	3.0	4.5
Crude protein, %	0	20.0	10.0	6.7	0	40.0	20.0	13.3
Daily gain, lb	0	.34	.30	.34	0	.52	.57	.59
Trial 1	**.4 lb Supplement Crude Protein/Day**				**.8 lb Supplement Crude Protein/Day**			
Supp/day, lb	0	2.0	3.5	5.0	0	2.0	3.5	5.0
Crude protein, %	0	20.0	11.5	8.0	0	40.0	23.0	16.0
Daily gain, lb	-.10	.41	.27	.11	-.10	.61	.75	.81

Table 6. Performance of Steers and Heifers Grazing Bromegrass or Cornstalks and Supplemented with Whole Soyhulls or Rolled Corn.

	Daily Supplement/Head		
	No Energy	3.0 lb Soyhulls	3.0 lb Rolled Corn
Bromegrass:			
Number of steers	16	16	16
Steer weight, initial, lb	564	564	564
Daily gain, lb	2.29	2.59	2.51
Lb suppl/lb added gain	--	10.0	13.6
Cornstalks:			
Number of heifers	16	16	16
Heifer weight, initial, lb	416	416	416
Daily gain, lb	1.62	1.98	1.87
Lb suppl/lb added gain	--	8.3	12.0

SELF-LIMITING SUPPLEMENTATION OF STOCKERS ON IMPROVED PASTURES

David P. Hutcheson

INTRODUCTION

Supplementing nutrients to cattle grazing pasture has been a profitable practice for several years. Most forages, including improved forages, are not always nutritionally balanced for the type and class of cattle that are grazing the pastures. For maximum production efficiency, cattle should be given certain minimum levels of nutrients. The nutrients that are commonly deficient in grazed forages are: protein, energy, phosphorus, and some trace minerals. Salt contains two important minerals, sodium and chloride, and are usually always deficient in grazed forages. Supplementation, which can be as simple as providing salt, has been shown to be profitable for cattle production when grazing forages. The use of self-limiting supplements can add profitability to a stocker grazing operation.

Supplements are given to cattle to improve their growth rate and extend the use of the forage.

Concepts

A supplement program needs to consider the type of forage that is available and the nutrients in the forage.

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The major nutrients necessary for growth of stocker cattle are: energy, protein, minerals, and vitamins. An example using wheat pasture will be discussed. Forage nutrient values can be chemically determined or published values may be used. Published values are usually averages and may not represent exactly the particular forage in question. Published nutrient values from the area do give an indication of what types of nutrients are available but the nutrient values are for the forage from that aera. Table 1 represents information from Beef Cattle Requirements published by the National Research Council, 1984.

Table 1.
Composition of Wheat.

Protein, %	28.60
NEm, mcal/lb	.79
NEg, mcal/lb	.50
Ca, %	.42
P, %	.40

Source: Nutrient Requirements for Beef Cattle, 1984. NRC.

The average values in the last column are similar to the average values in Table 1, however, they do differ slightly. Table 2 presents the average value of the nutrients for each month and the variance observed is influenced by forage growth and the environment. However, in determining the supplemental needs for beef cattle grazing this forage, an average value will be used. A 500 pound medium framed steer calf grazing wheat pasture that contains 21% dry matter is predicted to consume 13.1 lbs. of dry matter per day or, 62 lbs. (as is) wheat. This consumption should result in 2.45 lbs. of gain per day.

Table 2 represents nutrient composition of irrigated wheat growing from October to March in the Texas Panhandle.

Table 2.
Average Nutrient Composition of Wheat Pasture.

Dry Matter	Growing Month						
Nutrient	10	11	12	1	2	3	Average
Dry Matter, %	21.3	24.3	40.0	37.0	39.0	36.0	32.9
Crude Protein,%	26.9	21.4	22.9	19.0	20.0	21.6	22.0
Calcium, %	.25	.18	.24	.21	.20	.20	.21
Phosphorus, %	.23	.19	.15	.14	.14	.18	.17
Potassium, %	1.24	1.23	1.51	1.73	1.91	1.95	1.60
Magnesium, %	.21	.17	.17	.15	.12	.12	.16
Sodium, %	.02	.01	.04	.05	.08	.02	.04
Copper, ppm	16	15	10	9	13	10	12
Zinc, ppm	95	102	64	58	57	88	77

This calculation was accomplished by using the intake equation from the Nutrient Requirements for Beef Cattle (1984).

The equation that estimates the intake also assumes that the animal can consume this amount of dry matter per day. However, this means that 2.6 lbs. of wheat forage must be consumed each hour. Cattle grazing wheat do not routinely gain more than 2 lbs. a day. The lower gain that occurs is due to reduced intake of the forage. There are several factors that influence the intake of cattle grazing wheat pasture. Winter wheat grazing occurs during the winter and, at times, the weather can be detrimental to optimum intake. Metabolic disorders, such as bloat, are more prevalent in wheat pastures than other types of improved pastures.

Metabolic disorders, therefore, could be a potential deterrent of gain.

Last, but not least, balance of nutrients may influence the gain of cattle. Therefore, supplementation may improve intake and performance.

Table 3 illustrates the wheat intakes necessary for different gains of a 500 lb. steer. Most wheat pasture cattle gain 1.5 lbs. per day and the intake is estimated to be 48 lbs. wheat forage.

Table 3.
Forage Intake and Projected Gains.

Daily Gain	Forage Intake / lbs.
.5	29
1.0	37
1.5	42
2.0	48

Table 4 illustrates the mineral needs of this 500 lb. steer grazing wheat. The minerals calcium and magnesium are deficient. Therefore, if supplied in a 4 oz. intake package, the calcium needs to be 6.8% and the magnesium to be 1.1% with salt at 3.2%.

Table 4.
Mineral Needs of 500 lb. Steer Grazing Irrigated Wheat.

		Minerals from	
Mineral	Requirement	Wheat	Difference
Calcium, gm	30	12	-18
Phosphorus, gm	20	9	-11
Magnesium, gm	15	9	-6

Cattle will consume between .75 and 2 ozs. of salt per head per day when it is presented as a sole source product. Therefore, salt may be used as a limiter as well as an enticement.

Self-Limiting of Intake

Salt has been the most popular limiter because the salt is relatively cheap and at high levels limits consumption (Table 5).

When feeding salt as a limiter, it is important that clean fresh water always be available. From table 5, the higher levels of salt are necessary to limit lower levels of grain consumption. For instance, to limit a 700 lb. steer to 3 lbs. of grain per day, 19% salt should be added.

Fat has also been used as a limiter in self-limiting supplements. The percentages of fat that are needed to limit intake are approximately the same as percentages of salt in limiting supplements to cattle grazing pastures.

When using fat, several precautions have to be considered; one is the type of fat used. It is suggested that a good tallow be used rather than a blended mix, since blends do not always contain the same types of fat.

Table 5.
% Salt.

	Grain Intake Per Day				
Weight	3 lb	4 lb	5 lb	6 lb	7 lb
300	14	11	9	8	7
500	17	13	11	9	8
700	19	15	12	10	9

Fat may become rancid during hot weather unless antioxidants are added to these supplements. Of course, during cold weather fat mixing into supplements may be difficult.

Table 6 illustrates some data collected at the Texas Agricultural Experiment Station in Amarillo about variability of consumption of different types of projected intakes from self-limiting supplements. Intakes were higher than expected when .25 lbs was the projected intake. The .25 lb. intake had the highest weekly coefficient of variation of greater than 30%.

Table 6.

Projected	Actual	Cov	
0.25	.31	30.6	
	.38	31.0	
	.30	41.3	34.3
0.50	.51	21.4	
	.50	44.3	32.8
1.00	.80	10.6	
	.89	16.3	
	1.44	12.5	13.1
2.00	1.83	13.7	
	2.83	18.5	16.1

When half pound self-limiting supplements were formulated, the actual intakes were close to projected intakes. However, again, the variability was greater than 30% for weekly consumption averages. Supplements formulated for 1 lb. per head per day with limiters varied from .8 to 1.4 lbs. per head per day, but had a weekly coefficient of variation of 13%. The 2 lb. formulated supplements had intakes ranging from 1.8 to 2.8 for actual consumptions with the coefficient variations below 20%.

It is difficult to formulate supplements to target projected intake, but the variation of weekly intakes are less as the consumption increases.

Table 7 illustrates the expected additional gain of a 500 lb. steer at different consumption levels.

Table 7.
Gain from Supplemental Grain.

Supplement lbs/day	Expected Gain lbs/day	Feed to Gain
1	.12	8.3
2	.24	8.3
3	.34	8.8
4	.43	9.3
5	.51	9.8
6	.58	10.3
7	.64	11.0
8	.68	11.8
9	.72	12.5
10	.75	13.3

As supplemental grain consumption increases, gain increases but not linearly. Therefore, while additional gain occurs the cost of gain increases as evident by the increase in feed to gain. From this type of data, the economic optimal amount of supplemental consumption can be determined for different situations.

Forage growth and nutrient concentrations of the forage may change supplement consumption levels when self-limiting supplements are used.

Following are some examples of formulations of self-limiting supplements for cattle grazing wheat pastures (Table 8).

Table 8.

	1 lb/hd/day	2 lb/hd/day
Grain	72.5	88.25
Salt	6.0	3.00
Limestone	12.0	6.00
Magnesium Oxide	1.5	.75
Dicalcium Phosphate	4.0	2.00
Ionophore, mg/lb	180.0	90.00

The important considerations in these formulas are the combination of ionophores, salt, and magnesium oxide. These types of supplements will not always be consumed at projected levels, but after consumption begins, the salt levels may be adjusted to give projected consumption.

Table 9 represents a self-limiting supplement used for a protein deficient pasture. The ionophore, dicalcium phosphate, and salt are used to limit intake in this supplement. The actual intake was limited to .6 of a lb per day when fed to 300 lb. heifers grazing native pasture.

Table 9.

Native Pasture.	
Cottonseed Meal	69.05
Dicalcium Phosphate	10.00
Salt	8.00
Potassium Chloride	5.00
Alfalfa Dehy 17	5.00
Limestone	2.00
Magnesium Oxide	0.50
Rumensin 60(R)	0.20
Vitamin A, 10M	0.10
Selenium, .02%	0.10
Trace Minerals	0.05

Self-limiting supplements have been developed for blocks and liquids as well as pelleted forms. All supplements, except mineral supplements discussed, are pelleted. If self-limiting supplements are formulated in meal form, then care must be taken to avoid separation of ingredients.

The hardness of the block will contribute to the ability of the supplement to be limited as well as the ingredients in the formulation.

Liquid self-limiting supplements use fat, salt, and chemical limiters to achieve self-limiting.

Summary

Self-limiting supplements have been utilized to supplement stockers when grazing forages. There is not a set of guidelines that allows easy formulation of supplements. The determinations of the proper types of supplements and nutrients to be added can be calculated and guidelines can be developed using limiters. Limiters such as, salt, ionophores, or combinations of fat, minerals, or chemicals may be used to control intake of supplements as well as the physical forms of products (block and liquids).

HIGH-VOLUME, LOW-COST SUPPLEMENTATION OF STOCKERS ON IMPROVED PASTURE

David I. Bransby

INTRODUCTION

A common approach to research on supplementation of stockers grazing improved pasture is provision of relatively small amounts of supplement to correct deficiencies in diet quality, and to avoid or minimize substitution (reduced forage consumption per head resulting from supplementation). Several assumptions seem to be implicit in such an orientation, including one or more of the following: (a) supplementation is more likely to be cost-effective on low-quality pasture; (b) it is more profitable if supplementation increases average daily gain (ADG) than if it increases stocking rate; (c) profit per animal is higher in priority than profit per acre; (d) supplement costs are relatively high compared to pasture costs; and (e) the main benefit from supplementation is obtained through increased animal production.

The objective of this paper is to examine these assumptions for Alabama and other states with similar resources. It is not my intention to present an extensive literature review or to report in detail on research data. The aim is to present some ideas and raise some questions based on logical arguments, with limited support from preliminary results of supplementation experiments in Alabama.

ECONOMICS

Research on supplementation of stockers on improved pasture may be aimed at studying biological principles, but in many cases it is also intended to evaluate practices which apply almost directly to the production environment. Consequently, outcomes of such research need to be evaluated in economic terms. It is reasonable to assume that producers wish to maximize total profit. This is achieved by maximizing return per unit of the most limiting production factor. Most economists appear to agree that land is usually the most limiting factor in agricultural enterprises. Therefore, maximizing return per acre (and not return per animal) will usually result in maximization of total profit.

Because there is frequently some disagreement on this issue among forage agronomists and animal scientists, a simple example can be used to illustrate the principle. Assume that if one dairy cow is grazed on 1 ac, profit per animal (and therefore profit per ha) is $500. Alternately, assume that if two cows are grazed on the 1 ac, milk production per animal goes down, resulting in a profit of $300 per cow. However, profit per ac, or total profit, increases to $600. There are certain situations in which total profit will be maximized by maximizing return per animal, but these are rare (1).

Cost per lb of gain is frequently quoted in economic evaluations of feedlot and grazing research. However, for pasture-based beef production this is of little value in isolation of total number of lb gained and the value of gain. Total number of lb gained will depend on the total number of acres, the stocking rate (animals/ac), the ADG and the length of the grazing period. The value of gain is obtained from the difference between selling and buying price per animal divided by the number of lb gained per head. For example, if a 400 lb animal is purchased at $0.90/lb and sold at 700 lb for $0.75/lb, the buying price per animal is $360 and the selling price is $525. Gain/head is 300 lb. Consequently, value of gain is (525 - 360)/300 = $0.55/lb.

From the above discussion it should be clear that to maximize total profit in a grazing enterprise will require an

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optimum balance between ADG, stocking rate, cost/lb of gain and value/lb of gain. It is therefore critical to understand the interaction among these variables and how they interact with supplementation.

CASE STUDIES

Stockers in the Southeast may be grazed on high quality winter annual pastures, tall fescue (most of which is infected with the fungal endophyte, Acremonium coenophialum) or summer perennial pastures such as bermudagrass. Animal production from winter annual pastures is restricted mainly by low forage yields in mid-winter. Forage quality is high, with crude protein levels in excess of the generally recognized needs of growing beef animals. However, responses to small amounts of protein and energy supplements have been observed (2,3). The main factors limiting animal production from infected fescue pastures are low winter forage yields and low ADG caused by fescue toxicosis, while low forage quality is the main limitation of bermudagrass pastures.

States such as Alabama, Arkansas and Georgia have large poultry industries which generate enormous quantities of poultry litter. Disposal of this litter in compliance with safe environmental standards has become a major problem, despite the potential for using this material for a cattle feed ingredient and fertilizer. The region also has a large supply of hay, much of which is poor quality. Both hay and poultry litter are low-cost, high-volume feed resources which may have potential to improve productivity and profitability of pasture-based stocker operations. However, published research on this type of supplementation is limited (4,5,6,7). Consequently, several experiments have been initiated in Alabama to evaluate the feasibility of this approach. The aim is to use supplementation to increase stocking rate by deliberately causing substitution of supplement for forage, and also to increase ADG. Although the production data presented in this paper were generated from actual experiments, the major interest is in studying biological, ecological and economic principles, rather than concentrating on absolute results.

Broiler Litter/Grain Supplementation on Rye Pasture

In a 3-year grazing experiment +/- 450 lb steers were supplemented with a free choice ration of 50% grain sorghum, 40% broiler litter, 5% molasses, and 5% peanut hay while grazing rye pastures at four stocking rates from 1.25 to 4.25 head/ac for an average of 104 days (December to March). Steers also grazed rye at 1.25 head/ac without supplement, and were fed in a dry lot on the supplement ration only. The relationship between ADG (y) and stocking rate (x) for the supplement treatment was $y = 3.34 - 0.33x$ ($r = - 0.99$), and that between daily intake of supplement/head (y) and stocking rate (x) was $y = 5.40 + 3.13x$ ($r = 0.99$). These equations were used to generate the predicted ADG and intake values in Table 1. The supplement ration was valued at $60/ton. The cost of owning each animal (animal costs, including starter feed, medication and interest on purchase price) was assumed to be $30/head, while the cost assigned to pasture production was $90/ac. The value of gain was assumed to be $0.50/lb.

As stocking rate increased, ADG decreased but gain/ac increased, as did supplement intake/head. Feed costs/lb of gain increased sharply with stocking rate because of the associated increase in supplement intake and decrease in ADG (Table 1). In contrast, pasture costs/lb of gain decreased sharply as stocking rate increased because of the associated increase in gain/ac. Animal costs/lb of gain increased moderately with stocking rate due to the decrease in ADG. The net result was that the highest profit/ac occurred at a stocking rate of 2.25 head/ac. Important points to note from

this case study are: (a) grazing plus supplement at the economic optimum stocking rate was superior in ADG and profit to grazing alone at 1.25 head/ac and to supplement alone; (b) the economic optimum stocking rate did not correspond with the stocking rates at which ADG and gain/ac were maximized; (c) supplementation did not pay unless stocking rate was above 1.25 head/ac, and (d) overstocking reduces profit, even with supplementation. However, the main weakness in this study was the application of grazing alone at only one stocking rate.

Broiler Litter/Corn Supplementation on Bermudagrass

In the first year of a study in south-east Alabama +/- 450 lb steers grazed Coastal bermudagrass at 3 stocking rates with no supplement and at 5 stocking rates with ad lib. access to a 50/50 broiler litter/shelled corn supplement for a 140-day period. Pastures on which no supplement was fed were fertilized with 150 lb N/ac and P and K were corrected according to soil test, while those on which supplement was offered received no fertilization. Steers were also fed the supplement ration alone without access to grazing.

The relationship between ADG (y) and stocking rate (x) was $y = 1.6 - 0.23x$ ($r = -0.98$) for grazing only and $y = 2.73 - 0.06x$ ($r = -0.99$) for supplementation. Intake (y) was related to stocking rate (x) by the equation $y = 17.3 + 0.12x$ ($r = 0.76$). These equations were used to generate the predicted gains and intake values in Table 2. For the economic analysis corn was valued at $72/ton and broiler litter at $25/ton. Pasture and animal costs were assumed to be $50/ac and $30/head respectively. However, no pasture costs were incurred when supplement was provided because it was assumed that supplementation would have a high fertilizer value with nutrients applied to the pasture via animal excreta. Data in Table 2 suggest that this is a reasonable assumption because 10.2 tons of supplement were fed/ac at a stocking rate of 8 steers/ac. The value of gain was assumed to be $0.40/lb.

As stocking rate increased ADG decreased, but this was more pronounced without supplementation (Table 2). Response of ADG to supplementation was generally higher on bermudagrass than on rye, probably because of the lower forage quality of bermudagrass. It is likely that this was also the cause of the higher supplement consumption on bermudagrass, although forage species, years and supplement composition were confounded across the two experiments.

Costs/lb of gain showed similar trends to those in Table 1 for rye pastures. Supplementation resulted in a much larger increase in return/ac, probably because of the large associated response of ADG caused by the relatively low forage quality of bermudagrass. However, despite no annual pasture costs assigned to bermudagrass, maximum economic benefit in terms of return/ac was obtained from supplementation when stocking rate was increased. Furthermore, maximum profit/ac occurred at a higher stocking rate than that which provided lowest total cost/lb of gain.

On the other hand, this case study provides a good example in which the rationale for maximizing return/ac might be questioned: at the stocking rate of 8 head/ac which maximized profit/ac, only 12.5 ac would be needed to carry 100 head, and 800 head could be carried on 100 ac. Consequently, the assumption that land (and not money to buy animals) is the most limiting production variable could be in question for many producers. However, it could always be argued that even if animals were more limiting than land they should be stocked at a rate that maximizes gain/ac on a portion of the available land, while the balance of the land is put to some other use.

Other Case Studies

Two other supplement strategies under investigation in Alabama deserve mention. The first involves offering 50/50 broiler litter/corn supplement free choice on both infected and fungus-free fescue, compared to fescue alone. Advantages of supplementation in this study were: (a) increased ADG; (b) increased stocking rate; (c) no difference in ADG between infected and fungus-free fescue if supplement is provided; (d) animals could graze pasture throughout the winter with supplement; and (e) no pasture fertilization was necessary if supplement was provided.

The second experiment involved supplementing low quality hay on high quality rye + ryegrass pasture. Initial results suggest that this approach allows stocking rate to be increased with relatively little sacrifice in ADG. Hay was provided from the start of grazing in fall for the entire grazing period. Some producers claim that this practice may improve ADG by reducing diarrhea and subclinical bloat. However, there was little difference in ADG between animals with and without supplement at the low stocking rate, suggesting that this hypothesis did not hold. The biological mechanism involved is probably one related mainly to quantity: because animals consume some hay they consume less pasture, resulting in high forage availability and ADG at equivalent stocking rates in mid-winter, when compared to animals with no hay supplement. This approach shows considerable promise although neither field or economic evaluations have been properly completed.

CONCLUSIONS

Examples described in this paper have illustrated the following important principles: (a) in pasture supplementation programs substitution is not necessarily undesirable; (b) supplementation can be made profitable by increasing both ADG and stocking rate; (c) the relationship between supplement costs and pasture costs does not necessarily indicate the best supplementation strategy; (d) maximum profit does not necessarily correspond with the lowest cost/lb of gain; (e) the value of supplementation may extend beyond increased animal production, to fertilization, use of crop residues and animal wastes, etc., and (f) feasibility of supplementation should probably be analyzed in economic terms.

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Table 1.
Predicted production and economic responses to supplementation and stocking rate for stockers grazing rye pastures and supplemented with an ad lib ration of broiler litter, grain sorghum and peanut hay

Treatment*	Stocking rate (head/ac)	ADG (lb)	Gain/ acre (lb)	Daily supp. intake/head (lb)	Cost/lb of gain ($) supp.	pasture	animal	Total	Net return/ac ($)
G + S	1.25	2.93	381	9.3	0.10	0.24	0.10	0.44	23
G + S	2.25	2.60	608	12.4	0.14	0.15	0.11	0.40	61
G + S	3.25	2.27	767	15.6	0.21	0.12	0.13	0.46	31
G + S	4.25	1.94	857	18.7	0.29	0.11	0.15	0.55	-43
G	1.25	2.36	307	--	--	0.29	0.12	0.41	28
S	--	1.56	--	17.9	0.53	--	0.18	0.71	--

*Treatments: G + S = grazing + supplement; G = grazing only; S = supplement only in dry lot.

Table 2.
Predicted production and economic responses to supplementation and stocking rate for stockers grazing bermudagrass and supplemented ad lib with a 50/50 broiler litter/corn mixture

Treatment*	Stocking rate (head/ac)	ADG (lb)	Gain/ acre (lb)	Daily supp. intake/head (lb)	Cost/lb of gain ($) supp.	pasture	animal	Total	Net return/ac ($)
G	2	1.14	319	--	--	0.16	0.19	0.35	16
G	4	0.68	381	--	--	0.13	0.31	0.44	-15
G	6	0.22	185	--	--	0.27	0.97	1.24	-155
G + S	4	2.49	1394	17.8	0.17	--	0.09	0.26	195
G + S	8	2.25	2520	18.3	0.20	--	0.10	0.30	252
G + S	12	2.01	3377	18.7	0.22	--	0.11	0.33	236
S	--	1.48	--	23.6	0.39	--	0.14	0.53	--

*Treatments: G + S = grazing + supplement; G = grazing only; S = supplement only in dry lot.

SHORT-DURATION GRAZING FOR STOCKER STEER PRODUCTION

G. D. Mooso and D. G. Morrison[1]

INTRODUCTION

Much interest has been generated during the past several years in the potential of high intensity short-duration grazing for stocker production. The basic principles of short-duration grazing were recorded as early as 1777 by a Scotsman, James Anderson (Voisin, 1959). Also referred to as controlled grazing, this grazing method involves subdividing a pasture into many small paddocks to allow animals restricted access to areas of fresh herbage.

Short-duration grazing is based on the premise that plants will be protected from over-grazing or selective grazing by frequent movement to areas that have been given adequate time for regrowth (Savory, 1978). Savory and Parsons (1980) observed a favorable herd effect by concentrating stock into small grazing areas for a short period of time. Increased stock density improves the ability of stock to search all areas of a pasture and more effectively utilize all of the available forage thus improving efficiency.

The primary objective of most grazing management practices is to maximize profits by optimizing per animal production per unit area. Pasture productivity is a function of the amount of forage produced, the quality of the forage and the efficiency with which the forage is harvested. Under continuous grazing, stocking rate is the principle factor controlling the frequency and severity of defoliation. Short-duration grazing allows for greater control of defoliation by manipulating the stocking density, length of grazing and length of the rest period, thus allowing for greater potential for increased productivity (Heitschmidt and Walker, 1983).

The objective of this research was to evaluate the effect of grazing management on forage availability and quality and animal performance. This paper reports results of a comparison of short-duration versus continuous grazing for stocker production on ryegrass-clover and bermudagrass pastures.

PROCEDURE

Trial 1 - Ryegrass-Clover

A 4.0-ha pasture (Ruston fine sandy loam soil) was well-disked and planted to a combination of 'Marshall' ryegrass (39 kg/ha) and 'Dixie' crimson clover (13 kg/ha) in mid-September for 3 years. Phosphate, potash and lime were applied according to soil test results. Two nitrogen applications (56 kg N/ha) were made during the grazing season, the first in mid-November after three to five true leaves were visible on the clovers and the second in early February.

The 4.0-ha pasture was divided into two 2.0-ha pastures. One was continuously grazed (CG) and the other was used for short-duration grazing (SDG). The SDG pasture was cross-fenced with a single strand of electrified polytape into 15 paddocks. Angus-sired 10-month-old weanling steers were randomly allotted to each grazing method (740 kg beef/ha) in late November and grazed until the end of May (190 days) each year. Additional animals were added as surplus forage became available.

Trial 2 - Bermudagrass

A 2.0-ha pasture (Bowie fine sandy loam soil) of 'Grazer' bermudagrass was divided into two 1.0-ha pastures. One pasture was used for CG while the other was cross-fenced with electrified

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polytape into 10 paddocks for SDG. Both pastures were equally stocked with Angus-, Brangus- and Simmental-sired steers and/or heifers in mid-May and grazed until early October (141 days) for three years. Four applications of 56 kg N/ha were made at 5-week intervals during the grazing season.

Calves in both trials were dewormed with an anthelmintic treatment and vaccinated against contagious diseases before the study began. Steers calves were also administered a growth stimulant. Animal weights were monitored at 28-day intervals during the grazing season. Fecal samples were collected at 28-day intervals to determine gastrointestinal nematode egg counts.

SDG paddocks were sampled (two 0.25-m^2 quadrats/paddock) before and after grazing to determine forage availability and utilization. Continuous grazing pastures was sampled at weekly intervals. All samples were analyzed for crude protein and digestibility.

Animal performance data were tested for significance by least squares analysis of variance. Animal nematode egg counts were analyzed with repeated time analysis. Pricing assumptions for animals were based on average current prices at the beginning of the grazing season. Selling price was established on a 10-year average margin determined by USDA Market News Service.

RESULTS

Trial 1

Animals on short-duration grazing were rotated to a new pasture every 1-3 days depending on forage availability and utilization. Cycle length averaged 32 days, 3 days grazing and 29 days of rest before the next grazing. Forage availability, as measured by two samples taken from each paddock prior to grazing, was increased by short-duration grazing as compared to continuous grazing (Fig. 1). Increased available forage resulted in an increase ($p<0.05$) in stocking rate during March, April and May (Table 1). Analysis of samples taken from paddocks prior to grazing showed that grazing management had no effect on forage quality variables (Fig. 2 and 3). Grazing method had no effect ($p>0.05$) on animal performance (Table 2) averaging 1.03 kg/hd/d for 3 years. The increased stocking rate resulted in a 27% increase in animal grazing days and 141 kg/ha more beef produced. Grazing method had no effect ($p>0.10$) on the number of nematode eggs per gram of feces (Table 3). Assuming calves were purchased for $1.87/kg in the fall and sold for $1.65/kg in June, short-duration grazing increased net returns by $74/ha.

Trial 2

Several differences were observed between the results for grazing ryegrass-clover and bermudagrass. Animals on short-duration grazing were rotated into a fresh bermudagrass pasture every 1-2 days depending on forage availability and utilization. Cycle length averaged 23 days, 2 days of grazing and 21 days of rest before the next grazing. High forage availability associated with bermudagrass resulted in high average stocking rate compared to ryegrass-clover pastures. Forage availability was similar for both grazing methods except late in the summer when SDG paddocks had more available forage (Fig. 1). Average monthly stocking rate and animal grazing days were similar for the two grazing methods (Table 1). Grazing method also had no effect on either crude protein or digestibility (Fig. 2 and 3). A significant ($p<0.05$) increase in animal performance was observed for short-duration grazing for each of the 3 years of this study which resulted in an average 36% more beef produced (Table 2). Grazing method had no effect ($p>0.10$) on number of nematode eggs per gram of feces (Table 3). Assuming animals were purchased at the beginning of the grazing season for $1.87/kg and sold in the fall for $1.76/kg, short-duration grazing resulted in a $310/ha difference between grazing methods.

DISCUSSION

The lower gains for animals grazing bermudagrass compared to those grazing ryegrass-clover reflect the lower quality of bermudagrass. When stockers are bought and sold before and after a grazing season, gain per head must generally be above 0.7 kg/d for positive returns to occur. This was not achieved on bermudagrass.

Short-duration grazing had a positive effect on production and utilization of ryegrass-clover pastures. Ryegrass and clover plants were protected from frequent grazing which had a stockpiling effect on the pasture which increased carrying capacity of the pasture.

Short-duration grazing had a positive effect on animals grazing bermudagrass by increasing animal performance. Grazing method had no effect on forage quality and animals on continuous grazing had sufficient forage. Short-duration grazing evidently resulted in increased animal efficiency. Animals confined to a small area did not expend as much energy consuming forage as animals that were free to roam the whole pasture. This may indicate that increased forage availability per unit area of land increased bite size and therefore decreased required grazing time per day.

It has been suggested that removing animals from pastures for extended periods of time would eliminate a significant number of free-living infective nematode larva. A single anthelmintic treatment at the beginning of the grazing season resulted in egg counts well below the level at which economic damage may result.

The $69/ha/year cost for electric fencing reported in this study takes into account the labor required to install semi-permanent electric fencing (single strand of polytape and fiberglass posts) which remained in the pasture until the end of the grazing season. The producer could save on the cost of materials by using several portable reels that are moved with the animals, but this would increase labor. The cost does not take into account any labor to rotate the cattle every 1-3 days.

Along with potential benefits, which include frequent evaluation of forage and close inspection of the livestock, producers must also evaluate disadvantages of short-duration grazing. This practice requires more labor and management decisions must be made almost daily. Because cattle must be moved often, a producer can not be away for more than a day or two without delegating management decisions.

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Table 1.
Average monthly stocking rate of ryegrass-clover and bermudagrass pastures as affected by grazing method

Method[1]	Month						Mean
	- - - - - - - - - - - - - hd/ha - - - - - - - - - - -						
Ryegrass-clover	DEC	JAN	FEB	MAR	APR	MAY	
SDG	4.0	3.7	3.7	4.7	5.4	4.9	4.5
CG	3.2	3.2	3.2	3.7	3.7	3.5	3.5
Bermudagrass	MAY	JUN	JUL	AUG	SEP		
SDG	9.6	9.6	9.6	10.6	8.9		9.4
CG	9.6	9.6	9.6	9.9	8.4		9.1

[1]SDG = short-duration grazing; CG = continuous grazing.

Table. 2.
Effect of grazing management on animal performance, animal grazing days and total beef production

	Grazing method[1]		
Item	SDG	CG	Mean
Ryegrass-clover			
Animal performance, kg/hd/d	1.01[a]	1.05[a]	1.03
Grazing days, d/ha	835[a]	660[b]	748
Beef produced, kg/ha	834[a]	693[b]	764
Bermudagrass			
Animal performance, kg/hd/d	0.50[a]	0.38[b]	0.44
Grazing days, d/ha	1339[a]	1299[a]	1319
Beef produced, kg/ha	670[a]	494[b]	580

[a,b]Row means followed by the same letter are not different ($p>0.05$).
[1]SDG = short-duration grazing; CG = continuous grazing.

Table 3.
Influence of grazing method on animal nematode egg counts - 2 year summary

Grazing method[1]	Month					
	- - - - - - - - eggs/g of feces - - - - - - -					
Ryegrass-clover	DEC	JAN	FEB	MAR	APR	MAY
SDG	38	4	22	14	11	2
CG	42	22	12	1	1	2
Bermudagrass	MAY	JUL	JUL	AUG	SEP	
SDG	0	1	10	66	14	
CG	0	1	6	30	21	

[1]SDG = short-duration grazing; CG = continuous grazing.

Table 4.
Economic comparison of short-duration grazing versus continuous grazing on ryegrass-clover

	Grazing method[1]	
Item	SDG	CG
Estimated costs[a]		
Initial steer wt, kg	209	209
Initial animal cost @ $1.87/kg	390	390
Average stocking rate, hd/ha	4.5	3.5
Animal cost/ha, $	1729	1359
Pasture cost/ha[b], $	227	227
Electric fencing/ha, $	69	0
Miscellaneous costs[c]/ha, $	175	141
Animal performance		
Average daily gain, kg	1.01	1.05
Animal grazing days/ha	834	660
Gain/ha, kg	842	693
Estimated returns		
Gross returns/ha[d] @ $1.65/kg	2692	2149
Total costs/ha, $	2198	1729
Net returns/ha, $	494	420

[a]Based on 1990 input prices.
[b]Includes fertilizer, seed and land preparation.
[c]Minerals, veterinary supplies and interest.
[d]3% shrinkage and 5% sales commission deducted.
[1]SDG = short-duration grazing; CG = continuous grazing.

Table 5.
Economic comparison of short-duration grazing versus continuous grazing on bermudagrass

Item	Grazing method[1] SDG	CG
Estimated costs[a]		
Initial steer wt, kg	255	255
Initial animal cost @ $1.87/kg	476	476
Average stocking rate, hd/ha	9.4	9.1
Animal cost/ha, $	4470	4350
Pasture cost/ha[b], $	133	133
Electric fencing/ha, $	69	0
Miscellaneous costs[c]/ha, $	395	395
Animal performance		
Average daily gain, kg	0.50	.038
Animal grazing days/ha	1336	1297
Gain/ha, kg	661	493
Estimated returns		
Gross returns/ha[d] @ $1.65/kg	4950	4572
Total costs/ha, $	5068	5000
Net loss/ha, $	118	428

[a]Based on 1990 input prices.
[b]Includes fertilizer, seed and land preparation.
[c]Minerals, veterinary supplies and interest.
[d]3% shrinkage and 5% sales commission deducted.
[1]SDG = short-duration grazing; CG = continuous grazing.

Fig.1 Effect of grazing management on forage availability

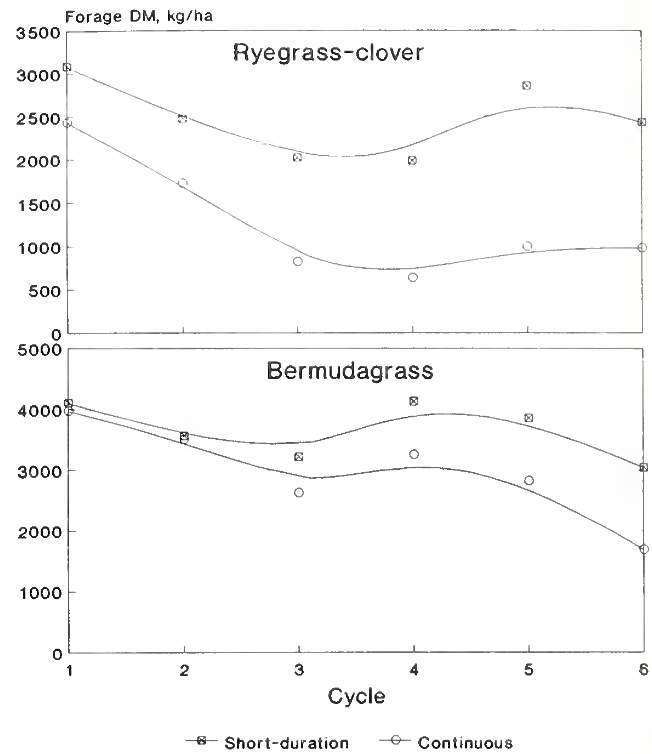


Fig.2 Effect of grazing management on crude protein

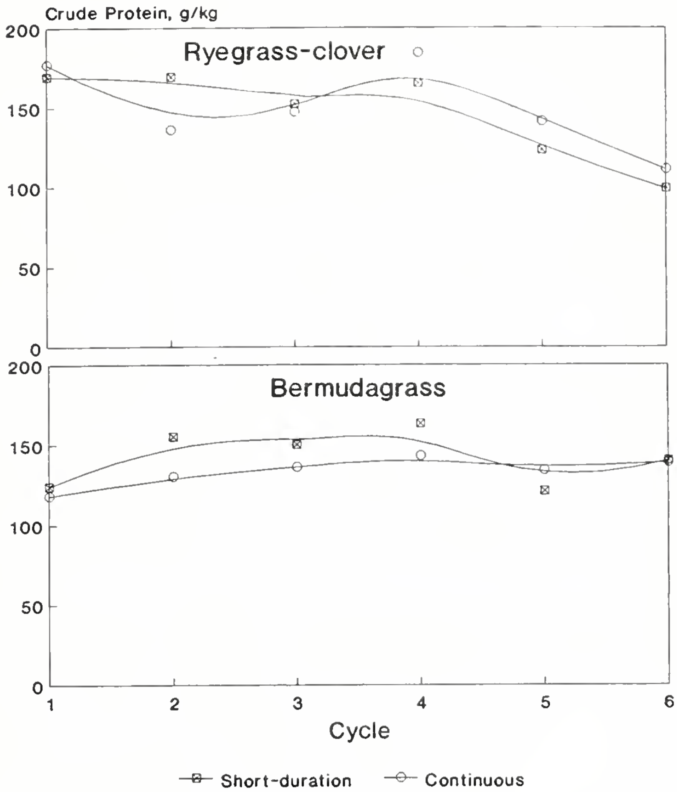
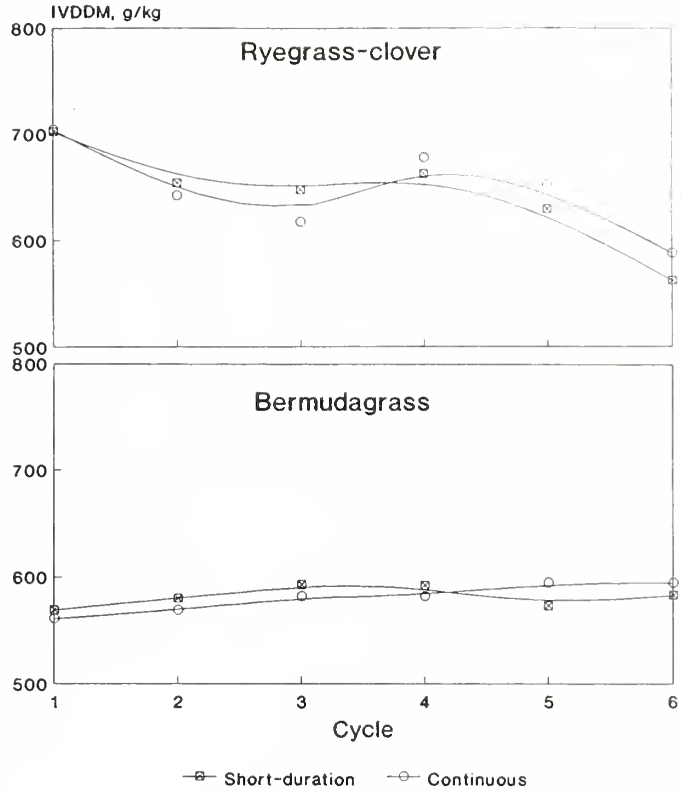


Fig.3 Effect of grazing management on digestibility



CERTIFIED ALFALFA SEED COUNCIL AWARDS PROGRAM

Donald M. Ball[1]

INTRODUCTION

For many years, the Certified Alfalfa Seed Council (CASC) has sponsored projects or activities supportive of extension efforts related to alfalfa. This has included the development of many fine publications, slide/tape sets, and videos; dissemination of data regarding alfalfa production; and sponsorship of the National Alfalfa Symposium.

In 1989, the CASC initiated an Awards Program. This program offers an opportunity to recognize individuals who have made outstanding contributions to the alfalfa industry, and to recognize outstanding producers on a state-by-state and regional basis.

AWARD CATEGORIES

Outstanding Alfalfa Producer State and Regional Awards- Any alfalfa grower is eligible. There can be one or more nominees from each state. Any person or group can submit a nomination. A state winner is selected for each state from which nominations are received. Four regional winners are selected from this group of state winners.

Alfalfa Research Award- Individuals presently engaged in any area of alfalfa research, and employed in either the public or private sector are eligible. Nominations by individuals, groups, universities or organizations are encouraged.

Alfalfa Extension Award- Persons presently engaged in teaching or extension, at either the university or county level, are eligible. Nominations from individuals, groups, universities, counties or organizations are welcomed.

Alfalfa Industry Award- Individuals employed in private industry (management, promotion, marketing, administration, etc.) are eligible. Nominations from individuals, groups, or organizations are encouraged.

Presidential Award of Excellence- A special award to be presented for excellence above and beyond the other awards. Recipients are selected by the Certified Alfalfa Seed Council's Operations Committee. This award is not necessarily presented every year.

RECOGNITION OF AWARD RECIPIENTS

The top nominee for the Outstanding Alfalfa Producer Award from each state receives a framed certificate acknowledging his or her achievement as a top producer within the state. Four regional award winners are selected annually from the state winners, and are invited to attend the National Alfalfa Symposium at CASC expense.

One person from among the nominees for each award are selected annually to receive the Research, Extension, and Industry Awards. These individuals are also invited to attend the National Alfalfa Symposium at CASC expense.

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SUMMARY

The CASC Awards Program should be of interest to Extension Specialists because it meshes well with state extension programs relating to alfalfa. It provides an opportunity to recognize individuals who have contributed to the alfalfa industry, while simultaneously focusing attention on alfalfa. In particular, the recognition of outstanding producers on both a state and regional level can create much good will, foster cooperation, and generate favorable publicity on which Extension Specialists can capitalize.

The address of the CASC is: P.O. Box 1017, Davis, CA 93617-1017. Solicitation of award nominations usually begins in October or November.

PROS AND CONS OF GRAZING ALFALFA

C.A. Griffith*

ABSTRACT

Alfalfa was established in the fall of 1980 at the Noble Foundation Headquarters farm to demonstrate the economic feasibility of grazing alfalfa with stocker steers. The results after four years are that alfalfa can be grazed successfully without bloat as a major problem with the use of Bloat Guard; average daily gains will exceed 2 pounds per head per day; and producing alfalfa hay is a better economic option than grazing.

ALFALFA ESTABLISHMENT

Three fields containing 34 acres were fallowed during the summer of 1980 to store moisture and to prepare a seedbed for a September planting of alfalfa. Tillage consisted of deep chiseling at 7 to 10 inches in soil depth. Then the soil was worked at three intervals with 1a plowing disc. Prior to planting, 1 quart of Tolban was incorporated into the soil. Three varieties of alfalfa--Apollo, Cimarron, and WL 318 were selected with highest consideration given to disease tolerances.

Fertilization during establishment consisted of banding 30 pounds of nitrogen, 20 pounds of P_2O_5 and 20 pounds of K_2O. Two fields received a broadcast application of 100 pounds per acre of 0-46-0 prior to planting.

Alfalfa was planted at the rate of 18 pounds of seed per acre. The seed was placed one-half inch in soil depth and in 8-inch rows. Excellent stands of alfalfa were obtained.

PLANT MAINTENANCE

The alfalfa was monitored closely for insects and had to be sprayed each year in February and March to control alfalfa weevil. Insecticides Lorsban and Encapsulated Parathion were used for weevil control.

The herbicide Sinbar was applied in February prior to the second growing season to control annual ryegrass.

GRAZING GUIDELINES AND MANAGEMENT PHILOSOPHY

The first consideration was what stocking rate to use. Based on an expected average annual production of 3 tons of dry matter per acre, a stocking rate of 1.9 head of steers per acre with a beginning weight near 400 pounds per head would serve as our guide. To compensate during good and bad years of production we would cut hay in the good years and feed hay if necessary in the bad years.

The next consideration was how the bloat preventive Bloat Guard[1] would be fed. It was our conclusion that the surest method for each animal to receive its designated quantity of Bloat Guard each day would be to hand feed it mixed in a grain cube. The grain cube containing the Bloat Guard was feed in troughs at the rate of 1 pound per head per day. The Bloat Guard was fed at 2 times the rate of the recommended dosage the first year but in later years was reduced to the recommended 5 grams per head per day. Feed troughs and water were located in an off area next to the alfalfa.

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[1]Bloat Guard is a brand of poloxalene manufactured by Smith Kline for the prevention and treatment of legume bloat in cattle.

Grazing management of the alfalfa took in consideration maintenance of the stand of alfalfa with optimum production, and to graze the alfalfa in a growth stage when it would have its least potential to cause bloat. In our case this meant grazing the alfalfa near the early bud stage of maturity or later. Also this meant we would not graze the alfalfa during extreme wet periods when cattle would bog. During off periods cattle would continued to receive the poloxalene feed and alfalfa hay.

The alfalfa was not grazed during the establishment year. This was to insure plants would be well rooted and fully established when grazing began.

Another consideration given to grazing management was cattle rotation. Alfalfa fields were subdivided into four pastures so that we could create a short graze period and then a minimum 20-day or longer rest period. Also having the 4 pastures gives us more flexibility in being able to harvest hay when needed.

RESULTS

A summary of cattle grazing alfalfa for the 4 years is shown in Table 1. The number of acres in alfalfa declined after the second year of grazing. This was due to a disease problem in 8 acres of the variety Cimarron that caused it to die out. The disease was associated with the type of soil the alfalfa was growing on and not due to grazing.

We increased stocking rate slightly the third and forth year. We felt we were too conservative in projecting the initial stocking rate. Also in the third and fourth year we included 18 acres of rye and clover as an additional pasture before steers would graze the alfalfa. The rye and clover allowed us to purchase cattle about 60 days earlier when the market was more favorable.

Bloat became a problem on 2 separate calendar days in the four years of grazing alfalfa. The first time was in the second year of grazing. We had 15 acute cases with 1 fatality. The alfalfa had a considerable amount of fresh regrowth after recovering from a dry spell. Cattle had a tendency to select the fresh regrowth over more mature parts of the plant. Also there was some question in regard to all the cattle receiving their daily allocation of Bloat Guard. The feed was put into the trough before all cattle were assembled. This made it possible for earlier arrivers to hog the feed. If we had not been monitoring the cattle on this particular day this certainly would have turned into a disastrous day. We immediately removed the cattle into the off area and an attempt was made to remove the intraruminal pressure before death of the one fatality. We observed the cattle for about three hours letting them eat hay and fed the Bloat Guard feed to them again. Then we rotated to another field containing more mature plants that we had originally scheduled to cut for hay. We did not have any more bloat problems with those cattle the rest of that season.

We had another case of bloat in the fourth year of grazing alfalfa. This time we had 2 head with acute bloat and 1 fatality. Again the problem was traced to cattle not all eating the feed with Bloat Guard. Some of the feed had gotten wet in storage and had a degree of mold that some of the cattle refused to eat. We replaced the old with fresh and this solved the problem. With a total of 22,151 steer days of grazing over the four years losing two head was insignificant in dollars. But as I mention earlier it could have been disastrous on one particular day if we hadn't been there to take care of the problem.

The average daily gain of steers grazing alfalfa was not ever below 2 pounds per day over the four years. Cattle had an average daily gain of 2.2, 2.3, 2.06 and 2.53 for the first, second, third and fourth year of grazing respectfully. We were very pleased with animal performance in grazing alfalfa. We have had difficulty in keeping average daily gains above 1.5 pounds per day with some of our grass grazing trials without supplemental feed. We can hold summer

gains on grass if we feed a protein supplement. An exception to this would be our crabgrass grazing trials where we have gotten equivalent gains.

A problem that we anticipated in grazing dry land alfalfa was the decline in forage production in July and August as compared to the peak growing months of April, May, and June. Our solution to this in the beginning was to harvest hay in round bales in the peak growing months and then feed the amount of hay necessary to get cattle through to late August and September when growing conditions would normally pick up. This is what we did the first year. We fed the cattle round alfalfa bales for about 30 days. During this time period the average daily gains dropped to 1 pound per day. With some quick calculations we immediately could see that this would be a very poor return for our alfalfa hay. Also when we had the option to sell the hay at a much greater return our solution in feeding hay was not a viable economic option.

The first year in grazing alfalfa turned out to be an above average year. Cattle grazed Alfalfa for 124 calendar days.

The second year we made the decisions that cattle would be sold when forage availability became a limiting factor. As it turned out forage became limited in late July and cattle were sold after grazing for 119 days.

The third and fourth year steers began grazing rye and clover in early March and then were rotated to alfalfa. The rye and clover was overseeded in bermudagrass in October of the previous year. We did this because we could get cattle bought much easier in February at less cost. Our thinking here was pure economics in that we would be buying the cattle cheaper and we would have a longer graze period on very high quality forages. Our beginning grazing dates were on March 14 and March 7 in 1984 and 1985 respectfully. In both years there was a short graze period on bermudagrass. In 1984 cattle had an average daily gain of 2.48 on rye and clover, 2.31 on alfalfa, and 1.00 on bermudagrass. In 1985 average daily gains were higher with 2.76 on rye and clover, 2.54 on alfalfa, and 1.69 grazing bermudagrass.

The whole purpose of grazing alfalfa was to determine the profit potential of purchasing steers and grazing alfalfa. I say this in regard to our previous experiences in running summer stockers on other summer forages. Table 2 is an economic summary of cattle grazing alfalfa for the four years. Only one year of the four did we show a profit. It was a return of $25.78 per acre. If we would compare this figure to baling hay and selling it on the market it would only have to bring $63.00 per ton to be an equivalent profit. The selling price of alfalfa hay during the four years of alfalfa grazing demonstration ranged from $85.00 to $120.00 per ton.

CONCLUSIONS

Alfalfa is a high quality forage that can be grazed through the growing season with average daily gains of 2 pounds per day or better. Bloat can be managed by feeding the recommended dosage of Bloat Guard to each head every day. It would be important however to monitor cattle each day during the morning period while grazing alfalfa.

The monthly forage production of alfalfa will coincide with peak periods of rainfall. This causes a build up of forage in May and June and then a rapid decline in available forage to graze in July and August. A combination of haying and grazing would make the most efficient use of surplus forage during the spring months.

Grazing alfalfa with stocker steers may not be the most economical use of alfalfa, particularly if there is an available market for alfalfa hay.

Other forages such as rye and clover can be used in combination with alfalfa to extend the grazing period.

Table 1.
A 4-year summary of the number of steers, acres of alfalfa and other forages, stocking rate, death loss, average daily gains, and the total number of days grazing alfalfa with steers.

Event	1982	1983	1984	1985
No. of head	66	65	60	55
Alfalfa acres	34	34	26	26
Rye-clover acres	--	--	18	18
Stocking rate (alfalfa, head/acre)	1.9	1.9	2.3	2.1
Death loss (bloat)	0	1	0	1
ADG--grazing alfalfa	2.20	2.30	2.06	2.54
No. days grazing alfalfa	124	115	61	56

Table 2.
The annual return to overhead, management, and risk for stocker steers grazing alfalfa for years 1982, 1983, 1984, and 1985 at the Noble Foundation Headquarters Farm, Ardmore, Oklahoma.

	Year			
Unit	1982	1983	1984	1985
Per head	$13.48	($3.20)	($44.07)	($13.46)
Per Acre	$25.78	($6.28)	($32.27)	($16.22)

Soluble Nutrient and Pesticide Potential For Surface and Groundwater Contamination

*Norman P. Bade

With the increased emphasis on water quality, there developed a need to evaluate potential losses of soluble nutrients and pesticides to ground and surface water resources. This paper describes two methods being used by the Soil Conservation Service (SCS) to determine potential loss of agricultural chemicals. Both methods are relative ratings and are based on the soils ability to retain the chemical until it is used by the plant or degrades to eliminate any pollution hazard.

The first rating system is the Soil-Pesticide Interaction Ratings[1]. It is being used to determine the potential for pesticide loss from leaching or surface runoff. It is specific as to soil mapping units and specific pesticides.

The GLEAMS[2] model was used to estimate pesticide losses from a large combination of soils and pesticides The soil and pesticide categories of potential losses are combined in a matrix to give a pesticide loss to surface water potential and a pesticide loss to leaching potential.

A pesticide loss was assumed to occur in the pesticide is leached below the root zone or leaves the field boundary in solution or absorbed on sediment suspended in runoff water.

The potential of losing pesticides from a field is a combined function of the pesticide, soil, and climate. In assessing the loss, a combination of soil and pesticide properties was used. The primary goal was to determine the capacity of a soil to retain a pesticide at the point of application, regardless of management or climate inputs.

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Several factors then were not considered in developing potentials. These include climate, the type of crop, application method or other soil pH, aluminum content, elements toxic to microbes and the total soil surface area.

Soils are ranked according to the relative potential for pesticide loss from surface runoff (surface loss potential) or leaching (leaching potential). The soil variables tested were surface horizon thickness, organic matter of the surface horizon, surface texture, subsurface texture and soil hydrologic group. Each soil mapping unit is rated as high, intermediate or nominal. These ratings are available on a county basis at SCS field offices[3].

Pesticides are also rated according to their potential for loss from surface runoff and leaching. The pesticide variables tested were half-life, solubility and organic matter partitioning coefficient (KO_c), The pesticide ratings were developed from the USDA-ARS Interim Pesticide Database[4]. Each pesticide has a rating of large, medium, small, or total use. These ratings are in SCS Technical Note No. 2, Water Quality[5] and is available from any SCS office. Pesticides with a large rating have a potential for unacceptable losses, regardless of management. Pesticides rated medium have a potential for unacceptable losses but may be reduced by management. Pesticides with a small rating have little potential for unacceptable losses regardless of management. Total use pesticides will probably never be lost.

1 "Pesticide - Soil Interaction Potentials for Loss" by Don Goss - USDA Soil Conservation Service, 1989.

2 "GLEAMS - Groundwater Loading Effects of Agricultural Management Systems" by R. A. Leonard, W. G. Knisel, and D. A. Still.

3 "Soil Ratings for Determining Water Pollution Risk for Pesticides" - USDA, Soil Conservation Service, Field Office Technical Guide, Section II, 1989.

These soil and pesticide potential ratings are used in a matrix to determine the overall potential for surface or leaching loss, depending on the water resource concern (groundwater or surface water). The resulting potential will provide the user the overall potential of loss when a specific pesticide is applied on a specific soil.

The potential pesticide loss to leaching matrix (Table 1) rates the potential of leaching as potential 1, 2, or 3. It combines the soil leaching potential of high, intermediate, or nominal with the pesticide leaching potential of large, medium, small, or total use.

The potential pesticide surface runoff matrix (Table 2) also rates potentials to surface loss as potentials 1, 2, or 3. It combines soil surface loss potentials of high, intermediate, or nominal with pesticide surface loss potentials of large, medium, or small.

The resulting potential (1, 2, or 3) can then be used in recommending treatment needs and alternatives. Potential 1 would indicate that the pesticide applied on the specific soil has a high potential of being lost to surface runoff or leaching. General considerations in using this pesticide include health hazards, sensitivity of water resource, and location of field relative to water resource. If the pesticide poses a potential problem, the use may consider alternative pesticides, alternative application techniques, biological control, or other crop management techniques.

4 "Interim Pesticide Properties Database" Version 1.0 by R. D. Wauchope, USDA-ARS, 1988.

5 Soil Pesticide Interaction Ratings - Water Quality Technical Note TX-2, USDA-SCS, April 1989.

Potential 2 is a gray area. The pesticide applied on this soil has the possibility of being lost to surface runoff or leaching. However, the possibility of loss is not as great as potential 1. Certain management techniques could reduce the hazard of loss. Some examples would include foliar application to reduce leaching potential, applications that are incorporated or banded to reduce surface loss potentials, and if rainfall probability is low, no appreciable loss would be expected.

Potential 3 indicates that pesticides applied on this soil have very low probability of being lost to surface runoff or leaching. This pesticide could be used according to the label with little hazard to the respective water resource.

To illustrate how the rating systems are used, assume weed control is planned on a Desan loamy fine sand, 1-8 percent slope. The herbicides considered are Dicamba and 2,4-D ester.

According to soil potential ratings, Desan has a high potential for leaching and a nominal potential for surface loss. Dicamba and 2,4-D ester have a small and medium surface loss potential and a large and medium leaching potential respectively (Table 3)

Using the surface loss potential matrix, a soil with nominal surface loss potential and a pesticide with a small (Dicamba) surface loss potential would indicate a potential 3. This should present no hazard to surface water. The application of a pesticide with a large (2,4-D ester) potential would indicate a potential 2 and some precautions should be taken and further evaluations made.

Using the leaching potential matrix, a soil with a high leaching potential and a pesticide with a large leaching potential (Dicamba) would indicate a high probability of leaching (Potential 1). Pest management techniques should be recommended. If the pesticide was rated as small leaching potential (2,4-D ester), the rating would be potential 2 and the pesticide would be less likely to leach if proper management was used. The ratings are not designed to provide specific pesticide recommendations, or limit the use of high risk pesticides. They do, however, provide for evaluation and the need for intensified management.

The other potential agricultural pollutant being evaluated is nitrate or other soluble nutrients. The method being used is Leaching Index (LI)[6]. The Leaching Index estimates the average annual amount of leaching below the root zone. The measurement is in inches. Percolating water which could contain dissolved nitrates or other soluble nutrients could be hazard to groundwater resources. The Leaching Index is a method to determine the degree of deep percolation in soils at specific locations. It is used to determine where intensive nutrient management practices are needed and where other practices which minimize infiltration should be recommended.

Soils for the purpose of determining potential for leaching are grouped into hydrologic groups. The soil hydrologic groups (A, B, C, or D) are recorded in published soil surveys or can be obtained from SCS Field Office Technical Guides. Climate data, specifically total annual precipitation and rainfall distribution, has also be evaluated. The combination of soils and climate was used to estimate leaching potential. The Leaching Index for specific soils in specific climates is available in SCS Field Offices[7]. Climate is specific to the recording location, total average annual rainfall (P) and rainfall during winter months (PW) (Table 4).

[6] "Water Percolation: An Indicator of N Teaching Potential" by J. R. Williams and D. E. Kissel.

[7] ECS - Water Quality Technical Note TX-1 - Soil Rating for Nitrate and Soluble Nutrients, USDA - Soil Conservation Service, April 1989.

The Leaching Index for each soil hydrologic group using climate data from College Station is then estimated in inches per year (Table 5).

In evaluating the potential for soluble nutrient leaching, values were grouped to provide relative risk. A LI below 2 inches would probably not contribute to soluble nutrient leaching below the root zone. A LI between 2 and 10 may contribute to soluble nutrient leaching below the root zone and nutrient management should be considered. At College Station soils with hydrologic groups B, C, and D are in this category (Table 5). A LI larger than 10 will contribute to soluble nutrient leaching below the root zone. Nutrient management practices should be recommended, soluble nutrients should not be applied or practices which minimize infiltration should be considered. At College Station soils with hydrologic group A fall in this category (Table 5).

We are using these tools, especially in sensitive water quality areas, to evaluate current and planned management practices with farmers and ranchers. Where the evaluation indicates a high potential for water quality degradation, nutrient and/or pest management is being planned.

Table 1

Potential Pesticides Loss to Leaching Matrix

Soil Leaching Potential	Pesticide Leaching Potential			
	Large	Medium	Small	Total Use
High	Potential 1	Potential 1	Potential 2	Potential 3
Intermediate	Potential 1	Potential 2	Potential 3	Potential 3
Nominal	Potential 2	Potential 3	Potential 3	Potential 3

Table 2

Potential Pesticide Loss to Surface Runoff Matrix

Soil Surface Loss Potential	Pesticide Surface Loss Potential		
	Large	Medium	Small
High	Potential 1	Potential 1	Potential 2
Intermediate	Potential 1	Potential 2	Potential 3
Nominal	Potential 2	Potential 3	Potential 3

Table 3

Pesticide Loss Potential

Herbicide	Surface Loss Potential	Leaching Potential
Dicamba	Small	Large
2,4-D ester	Medium	Medium

Table 4

Climate Data

County	City	P	PW
Brazos	College Station	37.89	18.88

Table 5

College Station, Texas

Hydrologic Group	Leaching Index (Inches)
A	14.3
B	8.6
C	5.0
D	3.2

THE MAKEUP OF HAY

B. J. Hankins[1]

There are roughly 62 million acres of hay grown annually in the United States. Animals that consume this 7 billion dollar crop perform either poorly or admirably based on its quality. There are five main constituents of hay that influence its quality. They are: moisture, protein, energy, minerals, and vitamins. Such factors as forage species, stage of maturity at harvest, weed control, soil fertility, weather, and geography all influence the five quality factors.

MOISTURE

Moisture usually comprises 12-15 percent of the weight of hay. Approximately six pounds of a conventional 50 pound bale's weight is moisture.

Moisture in excess of 20% found in 50 pound rectangular bales (perhaps 16% in 1,000 pound bales) at baling time results in a relative humidity of near 100% inside the bales (Lechtenberg and Hemken, 1985). This high level of moisture encourages mold growth which leads to a loss of dry matter, reduced feed value, and, in the worst cases, spontaneous combustion and barn fires. Green forage should be cured to a moisture content of less than 15 percent for safe storage. A portion of this curing can occur in the bale rather than all in the swath.

Excess moisture is also of concern because it adds freight cost as well as price per ton to purchased hay. Finally, moisture content in hay must be accounted for in calculating annual forage supply needs since rations are based on dry matter content of the forage.

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CRUDE PROTEIN

A second major constituent in hay is crude protein (CP). Some of the factors that influence its content are forage species, maturity at harvest, nitrogen fertilization, and leaf content. Its content may range from about 3% in the poorest to 25% in the best forages.

The amount of nitrogen in all plant protein is not constant. The protein in corn leaves, for example, consists of 14% N while the protein in corn grain consists of 16% N. However, since protein in forages consists of about 16% N, its content in hay is determined by analyzing for nitrogen and multiplying this percentage times 6.25. Thus, the term crude protein. In reality, only about 80% of the nitrogen in plant tissue is found in true protein. The remaining 20% is found in such other materials as amino acids, nitrate, etc. Therefore, CP actually over-estimates the amount of true protein in hay by about 20 percent (Shenk and Barnes, 1985). No problem is caused, however, by this 20% over estimation since these nitrogen compounds are also potentially digestible by ruminants.

Leaves are better sources of protein and other nutrients than stems. Therefore, every effort is made to produce, bale, and feed leafy forage. Leaf-to-stem ratios on alfalfa may be 1.4 at the late vegetative stage of growth, but decline to 0.7 at pod formation. The total leaf mass increases to flowering time then declines. Thus, harvest date influences leafiness and protein content of forage.

Some of the protein is not digestible because it is so tightly bound to other materials. However, there is a strong relationship between crude protein and apparent digestible protein (Reid, 1962). Apparent digestible protein (ADP) may be estimated from CP thusly: ADP = 0.929 (CP) - 3.48. If more than 12% of the total CP is bound, digestibility will be adversely affected. Hay that has heated will likely contain a certain amount of bound protein.

In these cases, nutritionists use available crude protein values reported by the forage laboratory rather than CP to calculate animal rations.

The CP content of first cut grass hay is about equal to first cut legume hay cut two weeks later (Lechtenberg and Hemken, 1985). Although grasses generally contain less protein than legumes, the quality of their protein is not inferior to legume protein.

ENERGY

The main purpose for feeding hay to livestock is to supply energy. All hay contains about the same amount of gross energy, but vast differences exist in energy digestibility.

Perhaps 45% of the energy in hay and other forages consumed by livestock is expelled as body heat. Only about 3% remains in the form of flesh. The remainder is discharged in the feces, urine, and gases.

Total digestible nutrients (TDN) is a term that expresses gross digestible energy. It is the physiological equivalent of digestible energy (Swift and Sullivan, 1962). TDN is the difference between feed nutrients consumed and that voided. The TDN value of hay is calculated by adding together the percentages of digestible protein, digestible carbohydrates and digestible fat x 2.25.

Because it does not account for the losses of energy due to fermentation in the rumen, TDN over estimates digestible energy in forages. However, it is a useful tool in forage evaluation. Leaf content of forages is a good indicator of TDN and forage intake by animals.

A number of equations have been derived to calculate forage TDN values. Some use crude fiber alone; others use a combination of fiber and crude protein. An example of such an equation is that used by the University of Arkansas to calculate the TDN content of tall fescue: $\%TDN = 58.4 + 1.034(\%CP) - 0.42(\%ADF)$. ADF in this equation stands for acid detergent fiber.

Hay, like all forms of plant tissue, is comprised of cells. The structural part of the cell, the cell wall, is also referred to as fiber. Excess fiber portends low quality hay, but a certain quantity is needed for proper rumen function. Low fiber intake and rapid fiber digestion contribute to faster intake by animals. Young forage contains less fiber and is more rapidly digested than more mature forage. Animals may eat as much as three times more young than old forage. Less than 40% to more than 80% of hay may be fiber. It is partially digested by animals via rumen fermentation. Leaves contain less fiber than stems. Alfalfa leaves may contain as little as 20% fiber while stems may contain 70% (Marten, et al., 1988).

Laboratory analysis is used to determine the amount of fiber in hay. One such analysis involves boiling a forage sample in neutral detergent solution. The total fiber determined in this way is called neutral detergent fiber (NDF). Neutral detergent fiber is an estimate of the cell wall content of forages. Since animals prefer low fiber hay, low NDF values are desired by farmers. NDF values may be used to estimate animal intake. Typical NDF values are: 75% for coastal bermudagrass, 68% for orchardgrass, and 40% for alfalfa.

A second sample of the same forage may be boiled in an acid detergent solution to determine the nature of the fiber. This second test determines the amount of fiber in the hay that is "digested" by acid. The portion not digested is called acid detergent fiber (ADF). ADF values are always smaller than NDF values because some of the cell wall (hemicellulose) is "digested" by the second boiling. Typical ADF values are 38% for Coastal bermudagrass, 41% for orchardgrass, and 29% for alfalfa. Again, small values are desirable.

The ADF material that remains after the two boilings consists of lignin, silica, and bound cellulose. Lignin comprises 3-20% of forage tissue and is associated with poor forage digestibility.

Animals receive energy not only from the digested cell walls (fiber), but also from the highly digestible material found inside the cell. Simple sugars, amino acids, organic acids, fats, and starch found there are essentially 100% digestible. Plant respiration and mold growth causes these materials to decline after hay has been cut.

MINERALS AND VITAMINS

Calcium (Ca) and phosphorus (P) are among the most important mineral nutrients in hay. Legumes contain 1.0 to 1.5% Ca and grasses 0.18 to 0.48%. Phosphorus contents of 0.14 to 0.3% are common. A ratio of two parts Ca to one part P is commonly fed in animal supplements. In alfalfa hay, the ratio ranges from 6:1 to 13:1. Since abnormally high Ca/P ratio can lead to impaired P metabolism, a salt-mineral mix low in Ca may be used when alfalfa is fed (Howarth, 1988). The combined amount of calcium, magnesium (Mg), and potassium (K) remains constant in forage, but calcium uptake may be reduced if potash fertilizer is applied too liberally.

Potassium is usually present in forage at levels of 1.2 to 1.5%. Hay cut in the vegetative growth stage will likely contain higher levels. If the ratio of Ca, Mg, and K becomes unbalanced in forages, grass tetany may result in cattle. A calculated ratio of $(\%K/39)/[(\%CA/20)+(\%MG/12)] = 2.2$ or less in plant tissue is desired to reduce the chance of grass tetany occurring.

Silica is more abundant in grass than in legume hay. Grasses commonly contain 2.25 to 5.9% of this material. Since it is associated with ADF, is indigestible, and may be abrasive to animal teeth, it is an undesirable entity in hay. In drought years, rice straw is used as emergency hay in some areas. Rice straw contains an abundance of silica.

Although it is unlikely to occur often, overliming can lead to zinc, iron, and manganese deficiencies in forages.

Even though vitamin A is found in green forage, its content declines with aging and weathering. The content of vitamin D increases in forages as they age and as they are exposed to sunlight.

ANTIQUALITY COMPOUNDS

In addition to the five quality constituents of hay mentioned above, a variety of antiquality factors may also be present.

Heavy applications of nitrogen fertilizer, drought, and cloudy weather are three factors that contribute to high nitrate concentration in hay. Poor milk production, abortions, and poor gains or death may result from feeding forage that contains nitrate-N levels that approach 1400-2000 ppm.

Alkaloids, saponins, a slobbering factor, prussic acid, tannins, dicoumarol, a bloat factor, and isoflavonoids are all undesirable materials found in certain forages under certain conditions. Special supplements, antidotes, and forage management practices may be used to reduce the likelihood of experiencing problems with them. The bloat factor and toxic levels of prussic acid are much less likely to be present in hay than in fresh forage.

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The Making and Use of Extension Educational Videos

Herb Brevard[1]

Video programs are being used by numerous state Extension services as an economical method of reaching large numbers of clientele.

The success of the video programs depends to a great extent on the quality of the production and the dedication of the specialist or agent utilizing the medium.

Video production is not a low cost endeavor. A rough estimate of $1,000 per minute of finished product is a reasonable starting point. If the videos are produced "in-house", much of the production cost can be absorbed as normal operating expenses. However, qualified staff and state of the art equipment must be available for quality production.

Regardless of whether the videos are produced internally or by commercial companies, several steps are essential.

A complete shooting-script and narration should be completed before any filming begins. The shooting script is a precise outline of the exact scenes needed to best illustrate the program content. Many "takes" may be necessary to give the video editor adequate choices for the final production.

Slight changes in both the shooting script and the narration may be necessary during filming. The smooth flow of the video, including transition of scenes and continuity of subject matter, is very critical.

Video is not the ultimate solution to presenting effective educational programs. It can, however, compliment many presentations. Well done videos can be used to replace speakers on programs, thus offering savings in travel and other expenses.

Videos offer excellent opportunities to bring demonstrations to an audience, thus allowing viewing any time during the year.

Internal training videos, such as "how to ---" may be produced with less sophisticated equipment. However, if the production is for public viewing, do not sacrifice quality.

Videos offer many opportunities in expanding the educational capabilities of the Extension services. Get advice from experts before proceeding. Select interesting topics and follow through with top quality production. Let people know what you have produced and promotes its use.

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MINUTES OF THE BUSINESS MEETING

46th Southern Pasture and Forage Crop Improvement Conference
Overton, Texas
May 7, 1990

The meeting was called to order by Chairman Rob Kalmbacher. The following actions were taken:

Old Business

1. Minutes of the 45th meeting were handed to participants and motion was made to accept as presented. Motion by W. Essig; seconded by J.P. Mueller. Motion passed.

2. A treasurer's report indicated a balance on hand of $5874.17 as of May 1, 1990. Motion to accept the report by J.C. Burns; seconded by Steve Schmidt. Motion passed.

3. Rob Kalmbacher announced that the proceeding of 1989 conference would be available in the summer 1990 because of printing and organizing limitations experienced by coordinator.

New Business

4. A motion was made by W. Essig to put the major part of SPFCIC funds into a 6 month CD; seconded by H. Hippke. Instructions were to check on cost and maintenance fee for checking account and CD. Motion passed.

5. A discussion was initiated to consider a SPFCIC directory and making it available to all workers and administrators in the Southern Region. K. Smith said AFGC had a format on floppy disc which could be used. G. Burton suggested a code for work area (research, teaching, ecology, physiology, breeding, etc.). N. Pratt suggested reprinting every 5 years with annual addendums. Estimated costs for 400 names requiring 12 pages would be roughly $500-600. Mail cost would be about $.15 each. D. Ball offered to check on cost at Auburn. Paul Mislevy made motion to develop a directory; seconded by Wade Faw. Motion passed.

6. W. Essig announced the 47th Conference dates and location: May 13-15, 1991, in Starkville, Mississippi.

7. R. Kalmbacher read a letter from Dr. Ann E. Thompson, Extension Director and Vice President of Auburn University, inviting the 48th Conference to Alabama in 1992. C. Chambliss moved we accept the invitation; seconded by M. Rouquette. Motion passed.

8. A report was made by the resolution committee, consisting of J. Bouton, S. Reeves and G. Mooso. They proposed:
a) Recognizing the efforts of D. Belesky for serving as AR coordinator from 1987-1990.
b) Recognizing the participation and contributions made by R.E. Coats and W.W. Woodhouse, both who died since last meeting.
c) Recognizing the efforts of Texas workers in organizing the 46th Conference.
Motion by D. St. Louis to send resolutions to appropriate people and print in proceeding; seconded by N. Pratt. Motion passed.

9. D. Fisher reported that Dr. Roger Gates had agreed to serve as AR Coordinator. Ken Quesenberry moved he be accepted; seconded by B. Stanly. Motion passed.

10. Nomination committee (D. Ball, K. Pond, W. Faw) recommended that Chuck Dougherty, U. of KY be elected as Chairman-elect. K. Quesenberry moved he be accepted by acclimation; seconded by W. Evers. Motion passed.

11. The gavel was passed to Ken Quesenberry, Chairman for the 47th SPFCIC. After presenting Rob Kalmbacher a plaque for his service, the meeting was adjourned.

Respectfully submitted,

James T. Green, Jr.
James T. Green, Jr.
Secretary
SPFCIC

FINANCIAL STATEMENT
1989-1990
Southern Pasture and Forage Crop Improvement Conference

Presented in Overton, Texas
May 9, 1990

	Income	Expense	Balance
06/05/89 Balance on hand at Wachovia Bank and Trust Account #6261 206760			6496.84
07/10/89 Don Holt for Arkansas		527.44	
07/10/89 Keith Bolsen Expenses for Arkansas		48.60	
03/19/90 Postal Account in Beckley, WV (David Belesky, R. Kalmbacher)		366.00	
04/30/90 Interest credited to account for period 6/6/89 to 4/4/90	319.37		
05/01/90 BALANCE ON HAND			5874.17

Respectfully submitted by
James T. Green, Jr.

Resolution 1.

WHEREAS, membership of the Southern Pasture & Forage Crop Improvement Conference has greatly benefited since 1986 from the contributions of Dr. David P. Belesky, Research Agronomist, Appalachian Soil & Water Conservation Research Laboratory, Beckley, West Virginia, as ARS coordinator which included assembling program papers and related records into the Annual Proceedings of the conference.

BE IT THEREFORE RESOLVED that the 46th Conference expresses grateful appreciation to Dr. Belesky for his unselfish and effective service.

Resolution 2.

WHEREAS, Marvin Riewe has participated actively in the Southern Pasture and Forage Crop Improvement Conference for more than 35 years serving as Chairman in 1969, and

WHEREAS, he has provided leadership in grazing research, design and methodology for the Texas Gulf Coast region and the humid Southeastern United States and for his 45 years of service to Texas A&M University.

BE IT THEREFORE RESOLVED that we recognize our friend and professional colleague, Marvin Riewe, and thank him for his many contributions to the improvement of forage and livestock production in our region, and wish him many years of happiness during his retirement period.

Resolution 3.

WHEREAS, Billy E. Conrad has participated actively in the Southern Pasture and Forage Crop Improvement Conference for more than 20 years, and

WHEREAS, he has provided leadership in teaching at Texas A&M University and advanced the knowledge of grazing pressure - available forage - animal gain relationships and contributed to the release of 'Kleingrass 75' and 'Brazos' bermudagrass.

BE IT THEREFORE RESOLVED that we recognize our friend and professional colleague, Billy E. Conrad, and thank him for his many contributions to the improvement of forage and livestock production in our region, and wish him many years of happiness during his retirement period.

Resolution 4.

WHEREAS, Billy Nelson has participated actively in the Southern Pasture and Forage Crop Improvement Conference for more than 30 years, serving as Chairman in 1985, and

WHEREAS, he has provided leadership in research in animal nutrition, especially forage quality evaluation, at the Franklinton, Louisiana Experiment Station, and whereas his work has provided much useful information to cattlemen and dairymen in the Gulf Coast region.

BE IT THEREFORE RESOLVED that we recognize our friend and professional colleague, Billy Nelson, and thank him for his many contributions to the improvement of forage and livestock production in our region, and wish him many years of happiness during his retirement period.

Resolution 5.

The membership of the 46th Southern Pasture and Forage Crop Improvement Conference mourn the passing of our friend and colleague, Robert E. Coats of the Mississippi Forestry and Agricultural Experiment Station. We will miss his work on the species evaluation and his promotion of forages.

BE IT THEREFORE RESOLVED that we express our sympathy and condolences to the family of Robert Coates.

Resolution 6.

WHEREAS, the membership of the 46th Annual Southern Pasture and Forage Crop Improvement Conference has gleaned much information and great benefits from its participation in the conference, and

WHEREAS, such information and benefits could not have been realized without the friendly, hospitable and concerted efforts of the staff and administration of Texas A&M University Agricultural Research and Extension Center at Overton, Texas.

BE IT THEREFORE RESOLVED that the 46th Conference express its grateful appreciation to the staff, faculty and administration of Texas A&M University for their gracious hospitality, imaginative programming, well planned and executed tour of the forage and livestock industry of eastern Texas, which was of great interest to the membership, and especially for their outstanding purposeful research to obtain answers to underlying causes and basic problems of forage and livestock agriculture.

THAT special recognition be extended to Dr. Charles Artzen, Deputy Director and Dean, Texas A&M; Dr. Robert Merrifield, Deputy Director, Texas Agr. Exp. Stn., Dr. Zerle L. Carpenter, Director, Texas Agric. Ext. Service; and Dr. Charles Long, Resident Director, Texas Agr. and Ext. Center at Overton and his support staff for their work.

SIGNAL RECOGNITION be extended to the individuals who served on the local arrangements committee:

Monte Roquette, Chairman; Ray Smith, Lloyd Nelson, Sim A. Reeves, Jr., Mark Hussey, and Gerald Evers.

TO: Tour Hosts - Gayle Finch, Tommy Barker, Jack Newbourn, and Jerry Stone.

TO: The Texas Forage Work Group

TO: Conference Chairman, Rob Kalmbacher; Immediate Past Chairman (and Program Chairman), Werner Essig; and Secretary, Jim Green.

TO: Session Chairman, Richard Joost, physiology-ecology; Mark Hussey, breeding; Steve Schmidt, utilization; and B.J. Hankins, extension.

TO: All who presented conference papers.

ADDITIONAL RECOGNITION is given to the following firms who contributed financially to the conference:

American Plant Food Corporation
Conlee Seed Co.
Delta and Pine Land Co.
Dow Elanco
E.I. duPont deNemours & Co.
East Texas Seed Co.
Postive Feed
Texas Forage and Grassland Council
Texas-Louisiana Aglime & Fertilizer Assn.
TV Electric Co.

The Resolution Committee, Southern Pasture and Forage Crop Improvement Conference
Galen Mooso
Sim Reeves
Joe Bouton, (Chairman)

Minutes for Ecology/Physiology Work Group Business Meeting

The meeting was called to order by the Work Group Chairman, Dr. C.P. West. A short discussion, concerning the format used in the session, followed. Dr. Donald Vietor suggested that a break be added to allow people to leave the meeting room for a short time and not miss any of the presentations or discussion. Dr. Paul Mislevy suggested that the extended time allowed for general discussion was good and recommended that this format be continued.

Following this discussion, Dr. West asked for nominations for the office of secretary. Dr. David Lang and Dr. Matt Sanderson were nominated from the floor by Dr. Geoff Brink and Dr. Ron Jones, respectively. Dr. Lang was elected by a show of hands.

Following the election, Dr. West asked for the introduction of any other business for discussion. There was an inquiry about the status of the proceedings of the 1989 SPFCIC meetings. It was explained that Dr. Dave Belesky, who had handled the publication of proceedings, had moved during the year and the publication process may have been delayed.

A motion to close the business meeting was presented by Dr. Donald Vietor and seconded by Dr. Galen Mooso. The motion passed and the meeting was adjourned.

MINUTES OF THE 46th SPFCIC FORAGE UTILIZATION WORK GROUP BUSINESS MEETING
Kilgore/Overton, TX
May 8, 1990

The meeting was called to order by Chairman Steve Schmidt at Kilgore, TX on May 8, 1990. A tablet was circulated for those in attendance to record their names, addresses, and suggestions of topics for future meetings.

An explanation was made that the minutes of the 46th SPFCIC Forage Utilization Work Group Business Meeting were not yet published because of difficulties with the publisher. A motion was made and seconded to dispense with the reading of the minutes of the 1989 business meeting held in Little Rock, AR.

The nominating committee, chaired by Dwight S. Fisher, presented F.T. (Butch) Withers, Jr., Animal Research Center, Mississippi State, MS as Secretary-Elect. He was unanimously elected. Dwight S. Fisher will serve as chairman for 1991.

A tablet that was being circulated for submission of ideas for future topics was pointed out.

A motion was made and seconded to dispense with introductions of the individuals in attendance.

Stephen P. Schmidt asked if there were any further ideas or business. Hagen Lippke said that this year's discussion was good and could have used a little more time. David Bransby asked if there was a consensus for more that 50-50 split for discussion and presentation. In general, the response was that 50-50 was adequate.

An announcement was made to be on the bus by 12:00 pm. The motion was made and seconded to adjourn.

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